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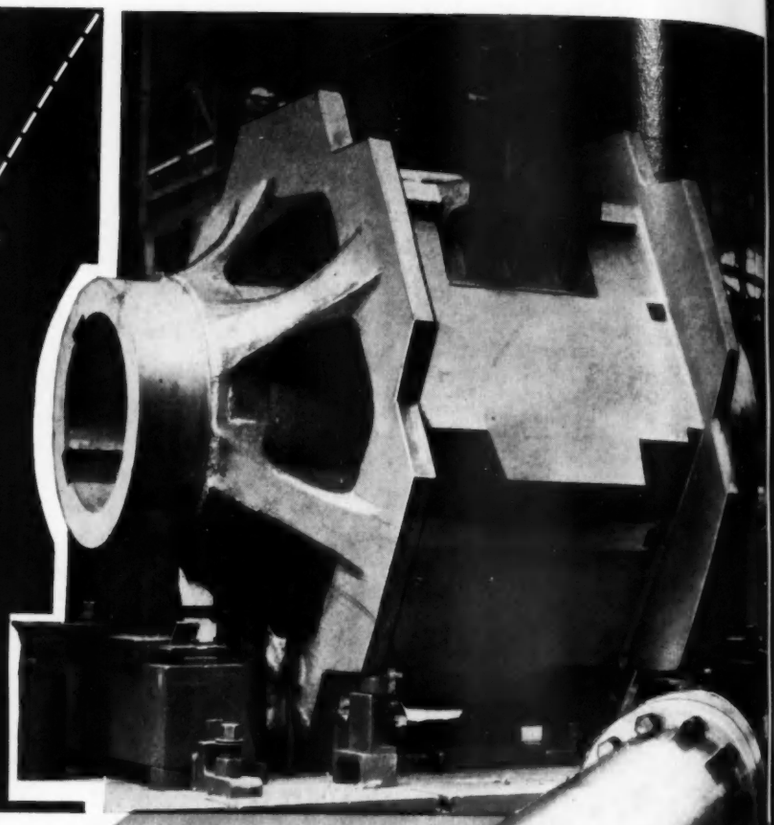

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EDITORIAL CONTENTS

Leading Articles

Commonwealth Technical Training Week . . . 845
Cosmonauts and Astronauts . . . 846
One-Way Traffic in Ideas ? . . . 846
An Outspoken Minister . . . 847
Electricity Shut-Down . . . 847

Articles

100 Years Ago . . . 847
A. J. Francis Science and Design in Engineering Education and Practice. No. I . . . 848
M. D. Bakes Digital Computer Programme for Critical Speed Calculations of Non-Uniform Shafts . 853
P. J. F. Wright The Durability of Concrete Kerbs . . . 855
H. Clausen Application of Elliptical Gear Wheels . . . 859
J. T. Leonard Grouting : Clay Based and Chemical . . . 864
Military Engineering . . . 866
Tower Cranes . . . 868
Research in Civil Engineering . . . 869
Testing Boiler Flue Gases for Corrosive and Fouling Tendencies . . . 870
Horizontal Facing Machine . . . 870
Industrial Health Clinic for Small Firms . . . 870
Economiser for Small Boilers . . . 871
High Vacuum Exhaust Steam Turbine . . . 871
Economiser Studies . . . 871
Transmitters for B.B.C. External Services . . . 872
Plastics Hose . . . 872
Reversible Locking Clutches . . . 873
Fluid Couplings for Control of Centrifugal Pumps . . . 873
London Traffic Survey . . . 873
British Investment Casters' Technical Association . . . 873
Faster Continuous Casting . . . 874
Type 3 Diesel-Hydraulic Locomotives . . . 874
Industrial Electrical Air Filters . . . 875
Radiotelephone for Small Craft . . . 875
Valve and Remote Control Assembly . . . 875
Packaged Substations with Air-Cooled Transformers . . . 876
Work Clamping Devices . . . 876
600 h.p. Diesel Hydraulic Locomotive . . . 877
Thermal Insulation of Steel Chimneys . . . 877

Continental Affairs

German Industries Fair at Hanover. No. III . . . 881
Association Technique Maritime et Aeronautique . . . 885
Enlarged Economy Car . . . 885
E.C.S.C. in 1960 . . . 886
Liability for Nuclear Damage . . . 886

American Scene

Yankee Atomic Power Station in Massachusetts. No. III . . . 887
Centennial of the Massachusetts Institute of Technology. No. I . . . 889

BOOK REVIEWS . . . 861

OBITUARY J. W. Ryde . . . James Newson . . . 863

NEWS AND NOTES Books of Reference . . . 863
Industrial News . . . 878
Personal and Business . . . 879
Indian Engineering News . . . 880
British Patent Specifications . . . 891
Advanced Engineering Courses . . . 892
Catalogues and Brochures . . . 892
Forthcoming Engagements . . . 892

INDEX TO ADVERTISERS : PAGE 109 **CLASSIFIED ADVERTISEMENTS : PAGE 100**

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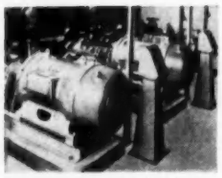

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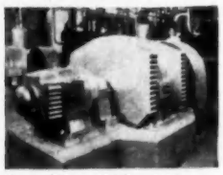

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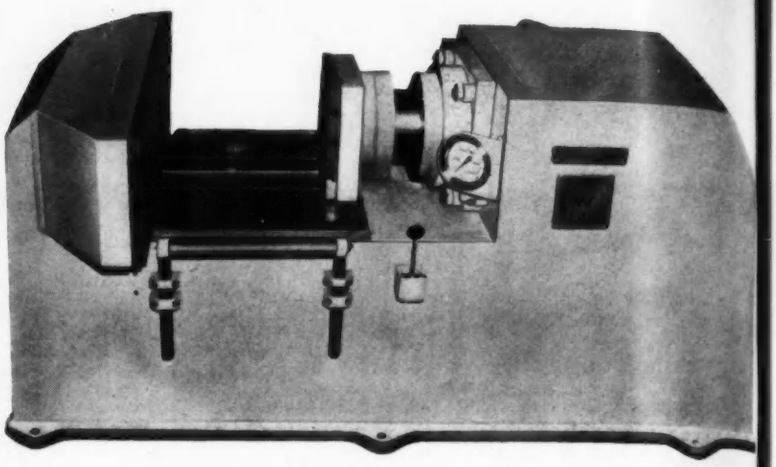

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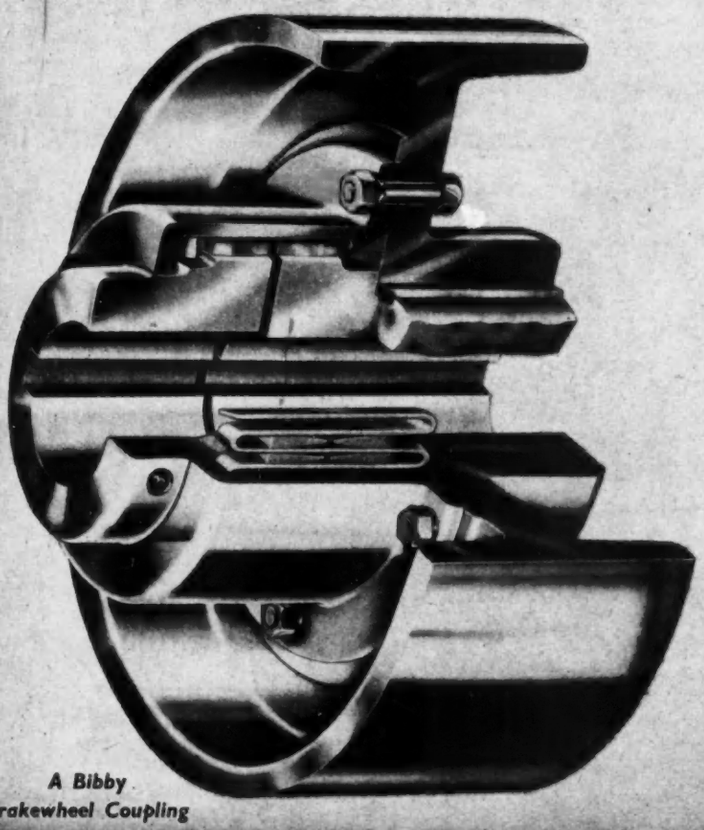

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THE ENGINEER

No. 5496 MAY 26, 1961 Vol. 211

COMMONWEALTH TECHNICAL TRAINING WEEK

Next Monday, May 29, the Duke of Edinburgh will inaugurate a "Commonwealth Technical Training Week" by presenting an Address at a meeting in the Guildhall in the City of London. The Week is to be celebrated in all parts of the country and many parts of the Commonwealth too. The holding of such a Week was suggested by Prince Philip himself, he has taken deep interest in its organisation, and during the Week he will make a large number of visits to various parts of the country. The idea behind the Week is to arouse the interest, particularly of young people, in technical training and to reveal the excellent opportunities there are for fruitful and lively careers in technical and technological occupations.

The body having administrative responsibility for the Week is the City and Guilds of London Institute. But local organisation lies in the hands of local authorities from which there has been forthcoming almost complete, if not indeed wholly complete, co-operation. The general plan will be modified in detail to accord with local ideas; but it is intended that everywhere the accent shall be on youth and functions are to be so organised as to attract young people. In most places there will be special church services and some kind of civic opening function. Factories will hold "Open Days" during the week so that parents as well as boys and girls will be able to see what goes on within them. Some may arrange to present special awards to apprentices. Technical colleges, to which many local authorities have delegated a good deal of the necessary organisation, will hold prize-givings, will be open for inspection, and will lay on information services. In most centres there will be careers exhibitions of some kind or another. In London there will be a service at St. Paul's cathedral, which the Duke of Edinburgh will attend; and there will be similar services at St. Giles in Edinburgh and at Llandaff cathedral in Wales and elsewhere. In London there will be a careers exhibition at the Royal Exchange and there will be a similar exhibition in Edinburgh. The major engineering institutions are taking part. The Institution of Civil Engineers is arranging to invite boys of sixth form standard from schools within reach of London to special programmes at its headquarters building at which eminent engineers will explain how a works is carried out from inception to completion by the help of drawings, designs, diagrams, charts and models. The Institution of Mechanical Engineers is laying on a small exhibition and members of the Education Committee will be available to provide information about careers and training to boys and girls, their parents and careers masters. There will also be a film show on May 30. The Institution of Electrical Engineers is to provide three lectures especially adapted for elder schoolchildren on the Tuesday, Wednesday and Thursday of the Week, respectively on colour television, new methods of generating electrical power, and the potentialities of artificial earth satellites for radio communication. The Institution's film "The Enquiring Mind," which deals with careers in engineering, will be shown after each lecture.

It remains to be seen whether the Week will really serve a purpose useful enough to justify the trouble taken to organise it. We confess to some doubt on the point. In a recent broadsheet of the City and Guilds of London Institute there appear the words "Commonwealth Technical Training Week must not be regarded as a mere seven-day wonder which in a matter of a few weeks can be looked back on as something attempted and something done, for there can be no past tense where young people are concerned. Rather must we regard it as the ceremonial opening of a great mission which will preach the gospel of training and education without cease." There we have the nub of the matter. If boys and girls are to find, are to be attracted by and are to be guided into technical jobs which will really suit them it is an all-the-year-round task to make the necessary information available to them. Elsewhere in the Commonwealth where communications are far less satisfactory than they are in this small and crowded country the holding of a Week may well justify itself. But here it should be possible, surely, so to organise matters that any boy or girl or parent wanting at any time to get information about opportunities and careers should be able to get it easily and quickly. If the Week draws attention to deficiencies in the information services available that will be an important service.

COSMONAUTS AND ASTRONAUTS

When Yuri Gagarin returned after making a single orbit around the earth in the Soviet "spaceship" "Vostok" he was hailed in the Press of this and other countries as a "cosmonaut," that is a traveller about the Cosmos. Making a delicate but, perhaps, invidious distinction the world's press does not seem to have felt that the American Commander Alan Shepard, whose capsule followed a ballistic course, could quite be termed a cosmonaut. He was hailed instead as an "astronaut," a traveller amongst the stars. Both titles were surely a little exaggerated? As we write we can see on the mantelpiece a globe. We find it useful in several ways, for example in discovering how true it is that the shortest route for an aircraft to fly from Scandinavia to say, Vancouver, lies across the Arctic. It is 10in. in diameter. Both the "cosmonaut" and the "astronaut" reached a height above the earth's surface of about 150 miles. Upon the scale of the globe this height is represented by less than a $\frac{1}{4}$in! In fact, though both Gagarin and Shepard went up to heights never before attained by man, both experienced conditions, such as weightlessness, never before experienced for long by man, and both went into regions lethal to man unless protected by capsules and space suits, they were really no less earthbound than the rest of us. How very far from being "astronauts" they were can be judged from the fact that the nearest star to the Solar System lies at such a distance that its light takes four years to reach us and that the system of stars called the "Galaxy," in which the Sun lies, has a diameter to be reckoned in hundreds of thousands of light years. As for a "cosmonaut," he would have to set off on a journey to some other galaxy, a mere matter of billions of light years distant!

But tiny though the distance the "cosmonaut" and the "astronaut" rose above the earth's surface looks upon our 10in globe, it constituted a much bigger step forward than it appears to be on that debunking scale. For the capsule which contained Gagarin attained a velocity of the order of 70 per cent of that necessary for a body to escape from the earth. It is already within the bounds of the practical for the Russians to "rocket" a man-carrying capsule right off the earth; but not, however, into the cosmos, nor even into the star-studded galaxy, only into the Solar System. The time can be foreseen to be not far distant when man will truly have started to navigate within the Solar System and to explore the Moon, Mars and Venus, the latter of which at its nearest is of the order of 30,000,000 miles away. But the time cannot be foreseen at all, it is buried so far in the distant future, when the first true "astronaut" starts on his way to explore whether other stars like the Sun possess planetary systems. At the distance of the Earth from the Sun a speed exceeding 100,000 m.p.h. will have to be attained in order to escape from the Solar System; moreover if the journey is to be completed within a lifetime a speed approaching that of light (186,000 miles per second) will need to be attained.

ONE-WAY TRAFFIC IN IDEAS?

The recent publication of the British Iron and Steel Research Association's annual report provides an opportunity for an appraisal of iron and steel research in Great Britain over the last few years. Looked at in one way the record is rather disappointing. Perhaps the most outstanding developments in iron and steel making in recent times have been the oxygen steelmaking process and continuous casting. Both were mainly developed abroad. Again great improvements have been made in blast-furnace practice, giving increased output with reduced fuel consumption; and vacuum casting has been developed to produce steels of hitherto unattainable purities: most of the credit for these two developments belongs overseas. There is ample material here for the pessimist, who will point out that a century and a half or so ago practically everything worth while in iron making originated in this country. That, of course, is true. But we might stop to consider that since Britain was then virtually the only country with a developed iron industry, it could hardly have been otherwise. Today, things are very different. Britain is far from being the only maker of iron and steel in the world; she is not even the biggest, and, because of geographical, geological and sociological conditions in certain other countries, she is unlikely ever to return to her old position. That is a simple fact which we cannot ignore and need not deplore unless, like our pessimist, we feel that Britain is now trailing along unhappily in the footsteps of her foreign rivals picking up and adopting, much later, the bright ideas they have had and developed. In short, if there is a one-way traffic of ideas — inwards to this country — we have cause to worry.

Steelmaking is international today, and there is a refreshingly free interchange of ideas and discussion of problems. Would that it were so in some other spheres! Research in every country is, or should be, related to problems in hand. That it is in fact so on the whole is evidenced when we look at the reasons why some of the new developments have taken place abroad. Continuous casting received a great impetus in Austria after the war because there was a shortage of scrap and the local steel works needed a hot-metal process which would use medium-phosphorous pig iron. A need for steel, a shortage of one material and the availability of another — there is no more compelling reason for developing a process to do the job in hand. Similarly, the Russians, determined to increase steel output at all costs, found the new process a valuable tool in their endeavour. The need was not so great here, but now that the process has been developed to commercial success, why should Britain not use it? To ignore an idea simply because someone else had it would be foolish, to say the least.

There is no national monopoly of ideas, and each nation, research organisation, firm, or, for that matter, man, is wise to devote all the time available to the most urgent problems, or to those which appear likely to show the best results. If Britain uses other people's ideas, at least she is not content to take them as they are and leave it at that. B.I.S.R.A. and a plant manufacturer have now jointly developed the continuous casting process in a way which both simplifies and improves it, and it should not be long before this idea begins to travel in the opposite direction. Again, B.I.S.R.A. has pioneered automatic control of forging and automatic gauge control for strip rolling. The latter is licensed for manufacture in this country, and negotiations have been started or completed for sub-licensing in Germany, Japan, Switzerland, Canada and the U.S.A. So there are some ideas moving out of this country as well as into it. We should do well to find out what both sides of the picture look like before we judge.

AN OUTSPOKEN MINISTER

There are undoubted advantages in being a Lord. One, less commonly appreciated than others, perhaps, is security in holding one's seat in Parliament. The ordinary M.P. must always be looking over his shoulder and wondering what his constituents will think of what he is saying and doing; and even the M.P. elevated to be a Minister of the Crown must toe the Party line and be wary of giving offence to colleagues or to pressure groups. But My Lord, secure in tenure of his seat, if not of his office, can feel much more free to speak his mind; and when he is naturally outspoken like Lord Hailsham the outcome can sometimes be quite startling. Since he became Minister for Science the enthusiasm of Lord Hailsham for the extension of research in this country and the improvement of education has been growing. So, too, has his admiration for the work of engineers and his conviction that their work should be pressed forward more vigorously. In this issue we print long extracts from the speech he made last Thursday in proposing the toast of the Institution at the annual dinner of the Institution of Civil Engineers. He pulled no punches. To an audience composed mainly of civil engineers he started off with a quotation from a Report of the Advisory Council on Scientific Policy criticising the "serious deficiency" in the research and development effort within civil engineering. He also laid a finger firmly on one of the troubles from which this country undoubtedly suffers when he said "Obsolete development is in a sense more insidious than lack of development," mentioning in the same breath docks, ports, railways, roads and bridges. But he went on to make a remark, which all civil engineers believe to be true, but which few would dare to make. "Engineering is by far the most artistic of the sciences." He followed up with a plea that teaching institutions might do more to teach engineering design and added "Let us bring about a situation when engineering will be recognised in this country — and particularly in the universities and in industry — for what it is; one of the most worthwhile and constructive occupations that a man, or a woman for that matter, can follow."

But Lord Hailsham's main plea was for the continuation and especially the expansion of civil engineering research and he said quite bluntly "this Institution has itself a responsibility and a role in this field." Is he not right? Is there enough research in civil engineering subjects? Quite a lot of research in those fields is done at universities and there is adequate work in specific fields covered by the Hydraulics Research Laboratory, the Water Pollution Research Laboratory, the Building Research Station, and the Road Research Laboratory and by bodies such as the British Hydrodynamics Research Laboratory. But does it amount to enough? Is it well enough co-ordinated? Is there, for example, room and need for a Civil Engineering Laboratory to operate in parallel with the National Engineering Laboratory (which used to be called the Mechanical Engineering Research Laboratory)? Or ought that last-named Laboratory to enter more strongly into the civil field? Perhaps Lord Hailsham was hinting that the Institution should take a more positive part in ensuring that research in civil engineering is both wide enough in coverage and intensive enough to support the needs of civil engineers in the present intensely competitive world.

ELECTRICITY SHUT-DOWN

As we stated briefly in last week's issue, an inquiry is being held by the Central Electricity Generating Board to investigate the electricity supply failure that affected large areas of south eastern England on the evening of May 15. It will probably take a week or two to establish the exact sequence of events and their causes which led to this widespread failure. In the meantime it would be premature to speculate very freely about the circumstances, apart from pointing out that the shut-down was the ultimate result of cascade tripping of protective devices on the circuits involved. It is known that the failure resulted in a loss of load approaching 1500MW after about twelve minutes. In the shut-down the following stations, under the control of the South Thames control centre, were "lost" — Deptford (East and West Stations), Belvedere, Croydon "B", Kingston, Littlebrook "A" "B" and "C", Woolwich and Brighton "B".

One of the factors that would have some bearing on the failure would be the amount of older generating plant taken out of service for planned maintenance at the time in question. This planned maintenance is carried out as far as possible outside the winter months during which the system faces its maximum demand. At such a time an unforeseen heating load, occasioned by a sudden drop in temperature, could cause a temporary shortage of spare plant in the system. The effects of such a situation could be particularly serious in south and east Kent where, as the C.E.G.B. has stated, urgently needed reinforcement of the main transmission lines has been held up by protracted difficulties over wayleaves. But whether and to what extent these circumstances helped to precipitate the failure will not be known until the committee of inquiry has completed its investigations. We look forward to the publication of the committee's findings, appreciating, as we do, the problems confronting the Board in its task of supplying electricity at minimum cost and with maximum security.

The Engineer—100 Years Ago (MAY 24, 1861)

"A Steam Gun"

"A new York paper gives the following description of a steam gun just brought out at Baltimore: 'It is on four wheels; the boiler is like that of an ordinary steam fire-engine, the cylinder being upright. There is but one barrel, which is of steel, on a pivot, and otherwise is like an ordinary musket barrel. It is fed or loaded through a hopper entering the barrel directly over the pivot. The barrel has a rotary motion, and performs the circumference by machinery attached, at the rate of about sixteen hundred times a minute. The balls are let into the barrel through a valve at will, and every time the barrel comes round to a certain point another valve, self-operated, lets out a ball, which is propelled solely by the velocity of the barrel in revolving. It will discharge a two-ounce ball three hundred times a minute. The range is accurate up and down, but the balls are liable to hit wide of the mark on one side or the other. The barrel revolves inside of a drum, made of boiler iron, between 5ft and 6ft in circumference, with an opening where the balls are discharged. Its range is not over one hundred yards at best, and the gun can be worked so as to discharge in any direction. The whole thing weighs 6,700 lb, and is about the size of a steam fire-engine. It is the opinion of our informant that the gun does not warrant the expectations of the inventor.'"

Science and Design in Engineering Education and Practice—No. I

ENGINEERING EDUCATION AND ENGINEERING PRACTICE

By Professor A. J. FRANCIS*

It is no doubt an indication of the keen interest being currently shown in the relationships between science and engineering design and research, &c., that we have independently received recently three articles on facets of the subject from three different countries, one from Mr. Hugh Clausen in this country, one from Professor Leyer, of the Swiss Federal Polytechnic at Zurich, and one from Professor Francis, of the University of Melbourne in Australia. All are critical of the education which engineers receive because of the stress it lays upon analysis rather than upon creativeness. The author of this article concentrates more completely than either of the others on education and training and he writes about English-speaking countries in general. The nature of the engineer's work is discussed, and it is concluded that he is primarily an innovator, a creator of articles for use. The philosophy underlying engineering training is then examined and is thought to be analytical rather than synthetic or creative in nature. It looks as though certain recent developments in the approach to teaching will increase this discrepancy. Suggestions are made for the improvement of design projects but it is thought that, for a real improvement to be effected, lecture courses too need to be realigned. Some specific suggestions in the field of structures are offered.

1. Introduction

EDUCATION in the western world to-day is notable for uncertainty of aim; whereas the Russians know where they are going, and back their system with ample funds and prestige, we are unsure even of the basic values on which our educational philosophy should be based. This uncertainty is greatest, and most serious, in primary and secondary education. In vocational education it is less obvious, but those of us who are engineering teachers are well enough aware of it. We are not clear, for instance, as to the engineer's proper relation to the rest of society. Much has been said about the place of the humanities in engineering education; some of it makes sense and some does not, and all that is really clear is that we have as a profession lost our self-respect.

Until recently the matter of whether we have in our education been encouraging the development of the type of skills which are most appropriate to engineering seems not to have been in doubt. Yet it is clear that the thought processes characteristic of various professions are very different. The lawyer, for example, is trained in words and the nice distinctions between words, to be able to hold large masses of facts in mind for a limited time, to assess and relate them to a massive body of statute and case law, and to exercise judgment to reach a conclusion on the evidence. In the doctor, a capacious and reliable memory and analytical (diagnostic) skill are of first importance. The architect, on the other hand, uses the creative rather than the critical or analytical faculties. He has a co-ordinating function, but he is also an artist. These characteristics are presumably reflected in the education for these professions. But what of the engineer?

2. The Work of the Engineer

Before we decide on the skills appropriate to engineers, it will be profitable to consider how we are employed as a profession, and the nature of a typical engineering operation. Engineers are principally engaged in the following activities :—

1. Research and Development.
2. Planning.
3. Design.
4. Construction.
5. Sales.
6. Maintenance.
7. Administration.
8. Teaching.

Most engineers work in groups 2, 3 and 4, which draws attention to the fact, obvious but sometimes forgotten, that the principal function of engineering is to make things for use; the engineer is essentially a creator. If he fails to produce anything useful he is not an engineer.

The process of producing something for use is an involved one, and the details vary with the article, which may range from a transistor radio through a large dam to a space vehicle; but certain steps are common to all engineering processes. They are as follows :—

1. Statement of the problem.
2. Collection and selection of relevant data.
3. Consideration of possible courses of action.
4. Selection of the course of action to be followed.
5. Detailed development of the course chosen, i.e. detailed design.
6. Construction (or production, in the case of mass-produced articles).
7. Maintenance.

We may consider as an example the building of a road in virgin country in New Guinea. The above steps can then be elaborated in the following way :—

1. The object of the road is stated : e.g., it is to go from A to B, bringing in other specified points en route. Traffic density, ruling gradients and curves and available finance are important parts of the problem.

2. The relevant data will include : Survey, topographical and soil, hydrological and geological; sources of raw materials; labour and equipment available.

3. Various routes which conform to the conditions of 1 and 2 are considered in some detail, and the cost of each assessed. In each alternative route choices have to be made, e.g. between bridges and embankments along a certain length, and decision, must be taken, perhaps without full knowledge of exact ground conditions, or as to whether certain available materials are adequate, or of other factors.

4. A choice has to be made between the alternative routes, the decision being made not only on the basis of cost of construction and of maintenance but of other less tangible matters such as speed of construction, the effect on the tribal life of the region and its natural resources, the relative scenic advantages, possibly even military considerations, and so on.

5. Detailed design of the selected route will include the preparation of drawings, quantities, specification, contract documents, &c.

6. The construction procedure to be adopted will have been taken into consideration in the earlier stages but there is still room for choice of method. Again decisions will need to be taken perhaps without all the facts at hand, and the engineer will depend on knowledge and experience in making up his mind.

All the stages are, of course, important, but steps 3 and 4 are the really important ones.

From the above discussion we can draw certain conclusions regarding engineering work :—

1. It is creative, requiring powers of synthesis as well as of analysis, the ability to synthesise being more important than the ability to analyse.

2. The important problems to be solved usually have more variables than equations, and the relationships are inequalities rather than equations (e.g. cost to be less than so much, working stresses not to exceed a certain value, loads likely to be less than so much, time of construction to fall between certain limits—the typical engineering problem is one in linear programming.)

3. Some variables are non-numerical and cannot be represented by mathematical symbols; aesthetic and sociological considerations, for example, are among these.

4. The important problems do not have unique solutions. There may be several of comparable merit, and the decision calls for the exercise of judgment.

5. Cost is of prime importance.

6. Design and construction (or production) are closely interlinked.

It is relevant to note here two points. The first is that the engineer usually works as one of a group, instead of giving the individual service of the doctor or lawyer. The second is that, except in routine work requiring no initiative, he must be willing to tackle a problem either unfamiliar or even one never before solved.

The nature of engineering was well understood by Tredgold when he framed his celebrated definition for the Institution of Civil Engineers, which begins with the words : " the art of directing the great sources of power in nature for the use and convenience of man."

Art there certainly is in engineering, as well as science. And the art is much more difficult to convey than the science. Wilbur[1] has defined the art of engineering as " that means by which we are sometimes able to reach understandings and results that could not be achieved solely on the basis of orderly, logical application of scientific analysis." In the example of the highway, its optimum location " may depend on a combination of political, legal, functional, economic, technical and aesthetic factors. Some of these

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aspects are susceptible to analysis, while others are not ; but, in any event, we seek the best location, thinking of the whole—that is, taking all these factors into consideration. . . . In the end, selections of this kind must depend on judgment, and the exercise of good judgment is not only an art, but a very fine art indeed. To be certain, the orderly, logical, frequently powerful tools of scientific analysis should be used to the hilt to serve as a guide to our judgment ; but herein we have an important truth ; analysis is frequently an invaluable guide to the art of judgment ; but it is rarely, if ever, a substitute for it."

3. The Nature of Engineering Teaching

Let us now turn to the educational scene in the Universities. How does it meet the requirements of the engineering profession? In the English speaking world there has been over the last fifty years a gradual movement in engineering curricula away from the teaching of practical applications and towards greater emphasis on pure and applied science. This is an inevitable and laudable development. There has been a great expansion in the theoretical basis of engineering, but no increase in the duration of courses, and the basic material has gradually squeezed out the treatment of engineering practice, with its details of bridge spans and types, water purification processes, construction methods, and so on. The time devoted to design has also in most places been reduced. I well recall the carefree but laborious weeks spent in my final year inking in rivets on sheet after sheet of structural steel drawings, and have no desire to see any student of mine doing the same. Courses to-day are far superior as a mental discipline to those even twenty-five years ago.

We have to ask ourselves, however, whether it is the kind of mental discipline most appropriate to a creative profession. I think that, by and large, and in spite of an exception here and there, universities have distinguished themselves more in critical and analytical activity than in creative endeavour. The mental processes traditional in the scholar are associated with patient discovery of the causes of phenomena. The scientific attitude is essentially analytical, the laying bare the secrets of nature. Universities have distinguished themselves most in recent times in the analytical fields of science. Creative art has not normally been at ease in the University atmosphere. University departments of fine arts and music are commonly noted for historical and critical scholarship, not as hotbeds of new ideas and movements in art or music. The analytical approach pervades university life. The new ideas in creative fields mainly appear elsewhere.

This philosophy long ago became deeply rooted in engineering schools, with what effects it is impossible to say. But I still recall two occasions in my life when I felt particularly at a loss. The first was when, as a raw research student, I was given the topic which I was to tackle, and asked to put up a proposal for a programme of research. The second was when, as a young engineer, I was given my first design (a small bridge) to carry out. I cannot help thinking that it was the absence of the creative approach in my university course, as well as my own natural ineptitude, which left me feeling unequal to the kinds of situation with which every engineer sooner or later is confronted. For it is true to say that the university approach to the teaching of engineering is analytical, not synthetic. One has only to examine the contents of courses and textbooks to determine this. Even better, let me quote an examination question in strength of materials typical of a hundred universities :

(*a*) Prove the relationship $f/y=M/I=E/R$ for a uniform beam subjected to couples

(*b*) A steel rule 13in by 1in by $\frac{1}{16}$in is bent by couples M at its ends. Calculate : (1) the maximum stress in the rule ; (2) the central deflexion ; (3) the anticlastic curvature.

The form is only too familiar to students and teachers alike. It involves (*a*) a piece of memory work and (*b*) an example linked to (*a*) and often consisting of hardly more than substitution in formulae. It may be remarked here that a tacit understanding seems to exist between examiner and examinee that (*a*) gives the clue as to how (*b*) should be tackled ; an examiner would not be playing the game if (*a*) bore no relation to (*b*) —if (*a*) were on the formula for torsion of a shaft, for example.

Now although such a problem—and it is representative in spirit of the kind of problem the student has been labouring on throughout the year—is good for the development of ability in structural analysis, it is useless as a means of training him to design and proportion structures. The problem is a clear-cut one, with all the essential but no extraneous data presented, the student is presented with a structure (however simple) which has already been designed, and he is asked to discover certain facts about it. Although the arithmetic is unfamiliar, the problem is not. There is one right answer, and only one. How different from the engineering situations the young engineer has to face in practice ; from the need to seek and select data, to generate solutions to the problem in hand and to choose the best solution on grounds of judgment which are partly scientific or mathematical but partly also non-scientific and intangible, involving ethical, aesthetic and even moral values.

This same remoteness from the creative aspect of engineering can be seen throughout university courses. In structural engineering the problems follow the same philosophical pattern as the one already quoted : a given structure is presented to the student, who has to discover something about it—perhaps a bending moment diagram or a deflection. Given the structure, the student becomes adept at analysing it. He is far less adept at creating the structure in the first place. We are training him in step 5 (detailed design) in the process of engineering design outlined earlier. I would not wish to minimise the need for accurate analysis, but skill in analysis alone is not the most important part of a designer's equipment. Far more money is lost by a wrong initial conception than can ever be recouped by careful detailed design.

Perhaps the greatest danger in the present emphasis on the analytical approach is that it may actually inhibit and stultify the creative instinct of the student. I believe this to be so both from my own experience and from my knowledge of students at the university and in later life. It is an interesting fact that, although architects generally have so little knowledge of structural theory as to arouse our scorn, new forms of structure are almost always pioneered by architects. Shell construction, exemplified by the Sydney Opera House and the Academy of Science Headquarters, Canberra, the cable roof of the Raleigh Pavilion, N. Carolina, the Skylon at the 1951 Exhibition, were all conceived by architects and made to stand up by engineers. The engineer limps along behind, a pathetically willing technical handmaiden, when he should be the pioneer of structural form. How far is his training responsible for this?

4. The Place of Design Projects

It will be countered at this stage that the proper place for the encouragement of the synthetic approach is the design class. It should be, but isn't. Design work is generally admitted to be the most unsatisfactory single part of engineering courses. The reason is that it is, as a rule, simply an extension of lecture courses in engineering science, an opportunity for the solution of similar problems on a bigger scale.

A typical structural design problem in any one of several dozen universities I visited in 1958 might well be a through-type steel plate girder bridge of 100ft span for a specified loading. In this simple statement the fatal step has already been taken, the important decisions have been made for the student, and he is confined to step 5 (detailed design) of the engineering process. Why was that span chosen? What are the site conditions? Why a steel plate girder bridge and not concrete in some form, or some type of space truss, or even a suspension span? Where do economics come in? Are we in fact wasting time polishing up something that must cost at least 30 per cent more than the most economical solution? These more basic questions are sidestepped. The guts of the design procedure have been neatly eviscerated.

I would not have it thought that I regard detailed design as unimportant. Errors in detailing have been responsible for many an engineering disaster, and the attention we give to it in our teaching is probably inadequate ; but I would like to see it put in its proper perspective as only a part—and a minor part—of the entire process. Too often, I fear, it does in practice become the major part. The training we receive as engineers is such that many of us are only happy when we get down to detailed design ; there is often little time in a design office for thorough investigation of alternatives ; the vital initial stages are dismissed with one wild stab at the solution ; and the final decision is a mockery of what it should be, with " what was done last time " looming large in the answer. The use of the reasoning powers in developing a design project should be the most exciting part of an engineering course. The active pursuit of some project, which has been described as the essence of modern educational method, can nowhere be better effected than in an engineering design class. But for a design project to carry conviction, it must have an air of verisimilitude and it must encourage the creative powers from the outset. Once the student feels that something, however small, has been decided for him, part of the effectiveness has been lost. Some of the points which should, I feel, be given consideration in a structural design project are detailed below.

1. The statement of the problem to be solved should be as realistic as possible ; preferably it should be an actual problem, simplified if necessary, but with no vital decisions made for the student.

2. In a small project all necessary data and information, and preferably some extraneous data as well, should be given ; in a large project the student should assemble these himself. The time of construction and maximum cost of the solution should also be given and the data should cover site conditions, the materials, labour and

equipment available, and accurate unit costs.

3. A study of alternative solutions, with costs, is essential before the selected solution is worked up in more detail.

4. Work in small groups should be encouraged, a group leader being appointed to organise the work of the group.

5. Competition between groups, e.g. on the basis of competitive tendering for the construction of the project, is a highly efficacious method of stimulating interest.

6. The project, if at all large, needs to be split into stages, the class being assisted along so that a proper proportion of the total allotted time is spent on the various stages.

7. Frequent group and class discussion is essential especially when alternative solutions are being considered.

8. A detailed report as well as drawings should be made by each student, and there should be a final class discussion on the solutions offered.

An example of a structural project for a class of twenty-two students which meets the requirements I have detailed is given in the Appendix. The desirable allocated time for such a project is 60 class contact hours.

5. Engineering Teaching in Different Countries

The attention given to the creative aspect in engineering education is, in overseas universities, generally limited, having regard to its obvious importance for engineers. The attitude to it in English universities seems to be in general as has been outlined. It is true to say that the English approach is strongly analytical.

" this lack of attention," quoted THE ENGINEER (June 6, 1959), " tends to lead to many British graduate engineers being inadequately experienced in the problems of design, and tending to believe that design is a lower grade of activity than research."

By comparison, as a group of English teachers reported recently after visiting German Technische Hochschulen, the emphasis in West Germany is on design. The quality of structural work in West Germany is quite outstanding. By comparison with Britain or the U.S.A., bridge design and construction are on an altogether higher plane, and one wonders whether there is a connection between this and the higher status and greater attention accorded to design in German engineering schools. In Britain, staff promotion comes by research, not by teaching ; competition for the higher-paid posts is severe, and the only measure in practice, as in Australia, is published work ; not unnaturally there is too little thought for the philosophy of engineering teaching. At the same time, British engineering teachers, by reason of their preoccupation with research and because far too few engineers with really broad practical experience (ten years or more) later make a career in University work, are often not well fitted to conduct design classes ; such chores are relegated to the old staff member with no interest in research.

From the point of view of the teaching of design, the German system seems altogether superior. It is common for a university teacher in Germany to conduct a flourishing consulting practice on a part-time basis, and there is close contact between teaching and practice at every level. To realise the effect of this one has only to glance at some of the structural textbooks published since 1945 by teaching staff of German engineering schools. The intimate blend of theory and practice that is achieved could be approached by very few university teachers in the English-speaking countries.

The scientific content of most American engineering first degree courses has been appreciably less than that of British or Australian courses. After the Second World War a reappraisal of engineering and scientific teaching began, and in 1955 appeared the Report of the Committee on the Evaluation of Engineering Education of the American Society for Engineering Education.[2]

More recently a report on Engineering Analysis and Design by a Committee of the same Society has appeared.[3] In spite of the recognition in these reports of the importance of the synthetic aspect of engineering training, a powerful movement has set in in the U.S.A. towards more and more science and less and less engineering in engineering courses, which threatens to swing beyond what is reasonable before its momentum is lost. Design work is being drastically curtailed, and practical experience is said to be becoming almost a liability when one applies for a university post. A philosophy is gaining ground which holds that engineering students should, as far as possible, be insulated from the practice of engineering. In the van of this movement is the Massachusetts Institute of Technology. Here and there a lone voice is raised in protest ; and at M.I.T. Professor J. B. Wilbur, Head of the Department of Civil Engineering, has been pleading for a better blend of the science and art of engineering. Holding much the same views as I have expressed, but going much further, he argues that students really ought to be exposed to the art of engineering before they are taught its science. Let them be given real comprehensive problems in engineering, like the location of an expressway across Manhattan, early in their course. The student really sees the need for engineering science when he has had to grapple with real problems first, and (as the American language puts it) is motivated to study. Treated in the broadest possible way, such design problems also make the student take an intelligent interest in non-engineering fields of knowledge : he finds that he must make up his mind on matters of aesthetics, economics, city planning, sociology as well as of engineering.

One fifth of the second year of the Civil Engineering Course at M.I.T. is now devoted to such design work. In 1958 the Volta River Scheme was chosen, and the group of about thirty-three students produced a most impressive report. To my mind the most interesting thing about this experiment is that it showed that students need not have been subjected to years of basic and applied science before they can work intelligently on a project involving hydraulic, structural, foundation and other problems. But it does demand a high staff-student ratio.

There is no doubt that design work can be very greatly improved. But to deal with synthesis in design classes only is not enough, if lecture courses remain entirely analytical in spirit. A recognition of the fact that engineering is also creative should permeate lecture courses, and this calls for some hard rethinking and entirely new approaches. I am convinced that the creative attitude cannot be inculcated too early, and differ from those who hold that synthesis can only be taught after the basic mathematics, pure and applied science have been given. It may be too late by then. By this time the non-academic reader will have lost all patience. " Why doesn't the fellow get on with his synthetic approach, instead of just complaining ?," he will say. Herein, of course, lies the difficulty. Hardly any textbooks on structures, for example, attempt to give more than the traditional analytical approach to the subject. They can be numbered on the fingers of one hand, and only one[4] carries the attempt very far, but in a descriptive way only. A teacher who is dissatisfied with the *status quo* must perforce do his thinking *ab initio*.

6. Suggestions for a Specific Lecture Course : Engineering Structures

It will perhaps help if I illustrate my point by discussing a possible attitude to the teaching of engineering structures, a field which, since it is more akin to one of the plastic arts than are most branches of engineering, is in particular need of a more realistic approach. Let me begin by quoting some unimpeachable authorities, the two most creative structural engineers of our time:

(i) " The prominence given to mathematics in engineering schools persuades students that it has limitless potency in theoretical calculations. Neither students nor teachers try to understand and feel intuitively the physical reality of a structure, how it moves under a load and how the various elements of a statically indeterminate system react among themselves "—(P. L. Nervi : " Structures ").

(ii) " The process of visualising or conceiving a structure is an art. Basically it is motivated by an inner experience, an intuition. It is never the result of mere deductive logical reasoning. . . . The work is never born from the calculation. The calculation of stresses can serve only to check and correct the sizes of the structural members as conceived and proposed by the intuition of the designer."—(E. Torroja : " The Philosophy of Structures ").

The anatomy of structures, still less their synthesis, cannot be understood by the student unless he has grasped certain basic facts which textbooks commonly omit to discuss adequately.

(*a*) *The Three-Dimensional Nature of Structures.*—In a three-dimensional world very few structures are really two-dimensional, although most of the common structural forms—the truss, building frame and so on—are plane units braced together to give three-dimensional stability. Structural thinking by engineers has been inhibited for too long by a training in plane statics, with a daring incursion or two into the third dimension. Our teaching ought to lay at least equal emphasis on the latter.

Three-dimensional statics, especially graphical, is an excellent means of encouraging the capacity to think imaginatively, and to visualise movement and deformation in space, a capacity vital to the understanding of structural action. (As one example of its value, the funicular surface, the three-dimensional equivalent of the funicular polygon, can be used to show very simply why a doubly curved surface is much stiffer and more efficient than a singly curved one.)

When engineers really begin to think and design in three dimensions, as many architects do, the results will be much more spectacular than anything so far achieved in the limited field of two-dimensional linear structures. For example, the possibilities of prestressing in three dimensions are far wider than in plane structures. But at present few engineers are capable of thinking along such lines.

(*b*) *Structural Form.*—The procedure of selection of the most appropriate structural form for a given use is a fascinating subject which is at present as nebulous as anything in civil engineering. It may be said that this is something that the young engineer will pick up in practice, but the exigencies of

professional life are such that this happens too infrequently. As I have tried to emphasise, this step in the design process is a vital one and serious study of the subject by universities is long overdue.

A discussion of the modes of structural action—axial (including membrane), bending, shear and torsion—with a consideration of relative economy of material and stiffness soon leads to the obvious conclusion that axial action, so long as buckling is taken care of, is the most efficient mode. It leads further to the less obvious conclusion that cables, shells (especially doubly curved ones), arches and pin-jointed frameworks are more economical in material for the same strength and stiffness requirements than forms in which bending predominates. This fact has been obscured by the success of research into the plastic behaviour of unbraced rigidly jointed frames. The three-bay portal frame shown in Fig. 1 can be designed more

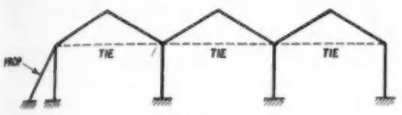

Fig. 1

economically if light ties and a prop at one side are added, so that the structure is converted from one with largely bending stresses to one with largely direct stresses. Headroom requirements may preclude the use of ties, but there must be many instances where the space provided under the roof is not in fact used. The old-fashioned roof truss, also, is often more economical of material and cheaper,[5] because the material in a triangulated truss is uniformly stressed, whereas the members of an unbraced frame, in spite of the refinement of plastic design, are still far from being uniformly stressed at collapse.

Directness of transmission of loads from their points of application to the supports is of basic relevance to economy of material, but again it is often overlooked in the preoccupation with specific structural types chosen from habit rather than for the suitability for the specific problem to be solved. Thus if we ignore considerations of the use of the interior space, a single load is most economically transmitted to supports *A*

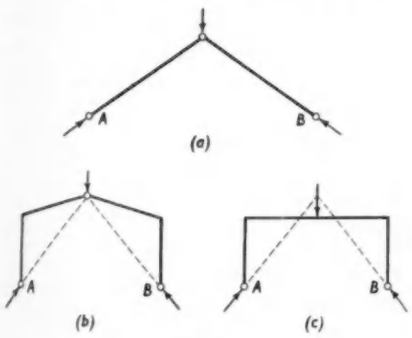

Fig. 2

and *B* (Fig. 2) by the arrangement (*a*), and least economically by arrangement (*c*).

These remarks are made, not with the desire to provoke controversy over plastic design philosophies, but by way of exemplifying the important fact that the arrangement of material for maximum strength and stiffness is a largely unexplored field. Very little progress has in fact been made, except in aircraft design, since the basic paper of Michell[6] fifty years ago. For example, since 1945 the balanced cantilever (Fig. 4 (*a*)) has become very popular in Germany for reinforced and prestressed concrete construction, instead of the traditional simply supported span (Fig. 4 (*b*)). The reason is obvious once one reflects on the effect of the dead weight. In the cantilever the maximum moments are nearest the support. The deepest and heaviest sections are thus located where they have least effect on the bending moments. In the ordinary beam the reverse is true : the heaviest sections are located in the centre of the span, where they exercise the greatest effect on the moments. In the cantilever the maximum deflections under distributed loads are also less. The economy in material resulting from the use of double cantilevers has justified their adoption. The remarkable thing is that such a basically simple idea should not have been hit on earlier. The subject is, of course, much more involved than the above discussion would suggest. The choice of materials, their relative tensile and compressive strengths and, in consequence, whether or not buckling is a serious possibility to be designed against, is only one of the factors which make the study of structural form intricate and difficult.

(*c*) *The Importance of Deformations.*—Too little attention is usually given to a study of structural displacements and deformations. Deformations are basic to an understanding of structural behaviour—more so than stresses—and too much time cannot be spent by the student in visualising how structures deform, both by imagination and sketching and by the use of models. This is especially the case with a statically indeterminate system, in which the distribution of internal forces depends on the relative flexibilities of different parts of the system. An increase in stiffness in part of an indeterminate structure attracts additional internal force to that part, though not additional stress. Where such a system can resist load by various modes of action in conjunction, it will do so by the stiffest mode if it can. As a simple example, a point load acting on a cantilever beam (Fig. 3 (*a*)) is resisted by

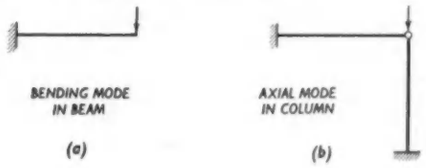

Fig. 3

bending action ; if a column is added (Fig. 3 (*b*)) the resistance will be largely axial, because the column action is stiffer than the beam action.

The same principle applied to shell structures explains why the principal mode of action in a thin shell is by membrane (i.e. axial) forces and not by bending.

A great deal can be learned about the action of a given indeterminate framework simply by intelligent sketching of deformed shapes[7] ; more use could be made of such procedures. Statically indeterminate structures, because of the greater difficulty of analysis, are looked on by students, and indeed by many practising engineers too, as on an altogether higher plane and superior in every way to the humble statically determinate structure. This is by no means the case ; for example, the lightest triangulated framework to carry a given set of loads has been shown to be determinate.[8] The rigid line of demarcation between determinate and indeterminate structures in most curricula is quite artificial.

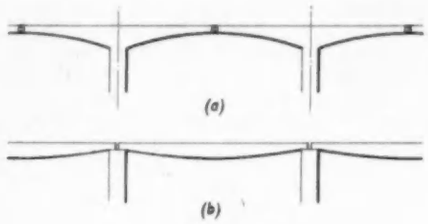

Fig. 4

Deformations are important also because as structural design becomes more refined, deflections rather than stresses or loads become the criterion in design.

(*d*) *Direct Methods of Design.*—As a further corollary to the teaching of structural theory, more emphasis ought to be placed on procedures of statically indeterminate design rather than analysis, in which something like an optimum structure is arrived at by a deliberate process. The approach exemplified by Grinter's method of automatic design[9] and the plastic moment distribution method[10] for rigid-jointed frames, Stevens' recently developed procedure for the design of frames of material of general non-linear behaviour for deformation criteria[11], methods of direct design of linear and non-linear triangulated frameworks[12] and the like needs more emphasis.

(*e*) *Economy.*—Economy of material usually, but not necessarily, means economy in cost. Cost is normally the most important criterion in the choice of a structural design, yet it is almost completely ignored in engineering courses. It is regarded as one of these practical matters that cannot be taught in a University course, or are inappropriate as not providing proper mental exercise, or for which the students' background of experience is inadequate—or perhaps because it is a subject on which practically no sensible information can be obtained either from books or the periodical literature. The viewpoint that a study of costs is inappropriate as being insufficiently stimulating intellectually for a university course cannot be sustained. Such a view would be rather unpopular in faculties of economics! I do not, however, have in mind the usual approach which consists of some lectures on quantity surveying followed by exercises in taking off quantities and multiplying by unit prices.

The cost of a structure depends on the materials used and the amounts of each used, on the labour and plant costs and overheads, and on the cost of maintenance, which is linked with the planned life of the structure. Labour and plant costs depend on the design, the method of construction, the degree of repetition or mass-production and on more uncertain factors like the weather. If the truth were known, we would probably find that many practising engineers are surprisingly hazy about costs. Yet there must be logical principles of structural costing waiting to be unearthed, and in spite of the uncertainties it ought to be possible to bring some degree of science to bear on the problem of relating design and costs in a systematic way. Investigation may show that some of the factors involved are under certain circumstances unimportant and can be neglected. Obviously, for example, the weight of material becomes a more important factor as the structure gets bigger.

An essential tool in such a course on structural anatomy is a free use of models of various suitable materials rapidly constructed by the student, either for qualitative information by deforming by hand to give

comparative behaviour, or (during an actual design) for quantitative information, by the actual application of loads. Synthesis on an intelligent level to produce the optimum structure is impossible without continual model work at these two levels—qualitative and later quantitative. These are ideas which receive scant attention in textbooks of analysis or even of design. To teach the subject of structure in such a way would need really hard thinking (in the absence of suitable textbooks) and rather radical departures from current teaching methods. In particular, design and lecture courses would have to be closely integrated. This would enable the wider use of the case study method, by which principles are driven home through the study of carefully selected problems. Such methods are more easily employed when design and lecture courses are interwoven.

Such an approach calls for research : research into structural form, into economy, into methods of design. In the minds of some people, I fear, there is a subconscious feeling that the only kind of structural research proper to universities is the kind which predominates at present—investigation, theoretical and/or experimental, of some aspect of the behaviour of a given type of practical structure. While such work is entirely necessary, it is not enough. The research worker probes into the action of a given type of structure with a view, certainly, to producing better (i.e. more refined) design procedures. The approach is largely analytical in nature, nevertheless. Very little thought is being given to the development of newer and more efficient structural forms.

Such a restricted view of research can be surprisingly inhibiting. Two examples will suffice :

(1) In multi-storey buildings wind loads are carried more economically by shear walls than by skeleton frame construction, and for this reason shear wall construction is coming increasingly into use. The delay in its introduction has been inexcusably long, however. The reason may well be, in part at least, that the people best fitted to understand its advantages and urge its adoption—the research workers—were too preoccupied in discovering all about the behaviour of skeleton frameworks (i.e. a problem as presented to them) to worry about whether some quite different system might not be altogether better.

(2) Instability of columns and other structural members has long been recognised as something which the designer should ensure does not occur, because of its catastrophic nature. Yet the great bulk of research into stability has been concerned with the behaviour of components as they are presented to the research worker, rather than with how the stability can be improved. For example, only in the last few years has a study been made[14] of the forces necessary at points along the length of a member in compression to induce a higher mode of instability and thus enable the member to develop greater resistance to bending or direct force. These forces turn out to be very small and can be supplied by light supporting or bracing members. The latter approach is creative, the traditional approach analytical.

The synthetic attitude in engineering is essential in the field of structures, perhaps more so than in some other branches of engineering. It may be that in electronics, for example, a less synthetic approach is desirable. A deeper knowledge of mathematics and modern physics is needed, and the element of art is much less obviously present. This will probably be true of the actual design of the article ; but the earlier steps in a design—the assembly of data, the investigation of courses of action and the choice of the course to be followed—these must be similar.

7. Conclusion

In this paper the question has been raised whether the philosophy of engineering teaching is correctly attuned to the most important function of the engineer, namely, to produce articles for use. The engineer is primarily a creator, whereas engineering teaching in the English-speaking world is primarily analytical in spirit. It follows from the arguments advanced that, with due respect to the need for analytical skill, more attention should be paid to the development of the creative faculty in engineering students. This is difficult to initiate : it is easier to teach analytically than creatively, scarcely any help can be got from textbooks, and practically all published work takes an analytical attitude. Another obstacle lies in the fact that a large proportion of engineering educators are too much out of touch with practice to be effective as instructors in creative design, and there is a need for some teachers to be continuously in closer contact with practice in their own field. In Australia an obstacle to this is the restriction placed on the consulting work of engineering teachers.

Experience indicates that the more a design project stimulates creative thought, the more students enjoy it, and the converse, unfortunately, holds also. It has been emphasised, however, that what is needed is more than a revision of design courses. The creative attitude needs to be infused into the presentation of lecture courses as well, and the teaching of structural engineering has been used to illustrate the points made.

In suggesting that engineering teachers do not approach their subjects sufficiently from the organic viewpoint I may be doing them a serious injustice. I should be more than happy if such were the case, but I fear the inhibiting effect of the typical textbook, in the structural field at least.

Acknowledgment

I am indebted to my colleagues in the Engineering School, University of Melbourne, for the stimulus received from many discussions on the general subject of this paper.

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APPENDIX

Project for the Bridging of River to Form Urban Highway

Outline of Scheme.—The river is to be roofed over between Bridges A and B, a distance of about 500 yards, to provide a new highway 100ft wide between parapets (see 1/2500 O.S. Map).

You are to suppose that the Corporation is calling for design-construct tenders for the job. The class is to form itself into three groups, each choosing a different medium of construction and competing for the work on the basis of a uniform set of unit costs. The three media will be (1) reinforced concrete ; (2) steel and reinforced concrete ; (3) prestressed concrete.

This assignment is an exercise in group planning and design of a structure. Each group will appoint a leader who will be responsible for the distribution of work between group members.

Attention should be concentrated on the section between the two bridges, and the tender price based on this section, but the design should be capable of being adapted easily to the curved section beyond Bridge B.

Highway Specification.—Two 11ft footpaths, two 36ft carriageways, one 6ft central verge ; total width 100ft. Uniform grade 1 in 150 between the two bridges falling from B to A. Road level at Bridge B : approximately 103·5 o.d.

Highway is to be structurally independent of the existing wharves and retaining walls.

Construction time : 1 year maximum.

River Requirements.—The River Board will permit two lines of piers in the river, not less than 60ft apart transversely. The existing headroom at Bridge A should be at least maintained throughout the structure.

The river is liable to sudden flooding. Maximum recorded level (1923) : 82 o.d. Normal water level 71·5 o.d.

Foundations.—The following borehole information may be taken as representative of the whole site :

65·5 o.d., top of sand and gravel bed ; 56·5 o.d., top of red sandstone (this is soft for top 3ft, and extends down indefinitely). Cofferdam construction is feasible.

Loads.—See Ministry of Transport Memo 577.

Unit Costs.—A full list of relevant unit costs will be issued.

Maximum Weight of Units.—Equipment likely to be available cannot handle and place units weighing more than 10 tons.

Approach to Problem.—The main variables to be considered by each group are :

(1) General structural form to be adopted ; (2) Direction in which main spans should run, i.e. longitudinally or transversely ; (3) Span lengths.

Each group should run out several designs and price them, in order to find the most economical layout. Simply supported beam layouts should be considered before statically indeterminate arrangements. The appearance of the structure is important.

It may be assumed that the foundations will be constructed by driving steel sheet piling cofferdams ; 3ft working room to be provided between foundation and cofferdam wall.

Three factors which will influence the design are : (*a*) the need to bring the work above flood level as quickly as possible ; (*b*) the possibility of repetition in the work ; (*c*) the need for speedy completion.

Submission Requirements.—Summarised calculations for various schemes considered, details of the final design and its price including cost per foot run of structure, two sheets of drawings, and a written statement of not more than 2000 words covering the design, method of construction and estimated construction time. Although the final design from a group will be a composite effort each student must make his own original submission of work. Reference in this to the work of other persons in the group will, of course, be essential.

THE ENGINEER

Technical Contributors Section

MAY, 1961

Digital Computer Programme for Critical Speed Calculations of Non-Uniform Shafts

By M. D. BAKES, B.A. (Cantab.)*

Although there are several well-proven methods for calculating the critical speeds of non-uniform shafts, the application of these methods to the digital computer has frequently brought to light a practical difficulty in getting the computer to "home" efficiently on to the exact critical speed, particularly when the computer is asked to calculate without any guide as to where the various critical speeds may occur. This article describes a programme that has been developed and used extensively in the author's organisation with consistently good results. The method of calculation is based on an earlier article by R. E. D. Bishop, in THE ENGINEER,† *and the adaptation of this principle into a fully comprehensive computer programme is given in detail. Various general comments and conclusions based on running experience with the programme are also given.*

BRIEF RESUMÉ OF MYKLESTAD'S METHOD

A FULL description of the mathematical method for calculating the critical speeds of non-uniform shafts is given in the original article†, and this need only be summarised here. Briefly, the original shaft is replaced, for the purpose of calculation, by a light shaft having the same stiffness, and carrying a series of particles to represent the mass of the original shaft. In order to allocate the mass to a series of discrete points the shaft is divided into a number of sections and the mass of any section is divided equally between its two end points, so that if the masses of two consecutive sections are m_r, m_{r+1} the point mass used on the idealised shaft at the face between the two sections will be $(m_r+m_{r+1})/2$. The mass and inertia at each section point and the length of each section must be supplied as data to the computer. Other information required is the number of masses in each idealised shaft, the position of the bearings, conditions at either end, and the range of speeds to be investigated.

The terminal conditions of the shaft may be of four kinds—free, simply-supported, clamped, or sliding. In terms of deflection V, slope θ, moment M, and shear force S, where V and θ are measured relative to the static configuration, these four conditions are as follows :

At a free end S, M are zero, V, θ unknown.

At a simply-supported end V, M are zero, S, θ unknown.

At a clamped end θ, V are zero, S, M unknown.

At a sliding end θ, S are zero, V, M unknown.

Here the end point is taken to be an infinitesimal distance beyond the final mass. This convention for shear forces is applied throughout the shaft, so that immediately beyond the first mass the shear force is $S_1 - M_1V_1\omega^2$ where S_1 is the shear force due to the support, if any.

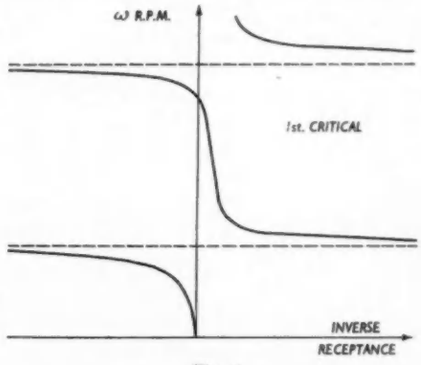


Fig. 1

For any initial condition there are always two unknowns, say X and Y, and we redefine the four initial values of the variables V_1, θ_1, M_1, S_1 in the form a_1X+b_1Y. Using the recurrence relations derived (*loc. cit.*) we calculate the final V, θ, M, S in the form a_nX+b_nY, where n is the number of masses in the shaft. We then have two end conditions :

(1) Where either θ or M is zero.

(2) Where either S or V is zero.

The second condition is used to eliminate Y. The inverse receptance M/θ, in which X is eliminated, is then calculated.

In the case of a free or simply-supported end, this ratio becomes zero at a critical speed, since in this condition a unit moment will produce infinite slope. When a speed is found such that the inverse receptance r is zero, we have discovered a critical.

In the case of a sliding or clamped end, the ratio becomes infinite at a critical speed, since an infinite moment is produced by a unit slope. The method of arriving at a critical in the case of free or simply-supported ends is described below, while a similar procedure, differing only in detail, is used for the other two end conditions. The case described is the one that occurs most frequently in practice.

METHOD FOR "HOMING" ON TO THE CRITICAL SPEED

In the article previously referred to, no method is suggested for quickly arriving at the critical speeds once the inverse receptances have been found. The chief difficulty is that unless reasonably close intervals of speed are chosen, in certain cases critical speeds can be missed or partially indicated so that the ensuing interpolation gives a wrong answer. If, however, very close intervals of speed are initially chosen, a great deal of unnecessary computer time can be wasted, this particularly being the case for a large general-purpose programme such as the present one.

The present programme is divided into two parts which briefly do the following :

(1) Scan the whole requested speed range at large intervals of 250 r.p.m. and select sets of three in which critical speeds are indicated.

(2) Examine the selected sets of three and use homing techniques to find the exact critical speed.

* The General Electric Company, Ltd., Engineering Computer Services Dept.

† "Myklestad's Method for Non-Uniform Vibrating Beams," by R. E. D. Bishop, THE ENGINEER, December 14 and 21, 1956.

Technical Contributors Section (*continued*)

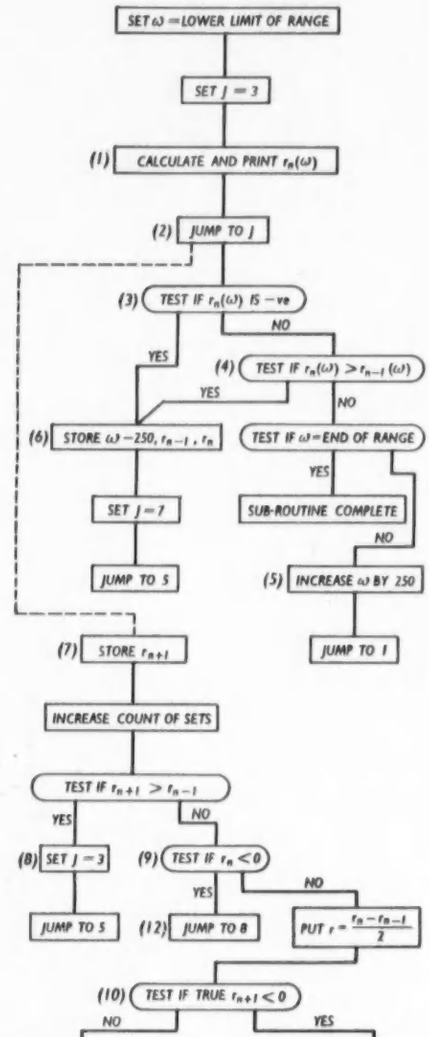


Fig. 2—Simplified flow diagram of sub-routine for recording sets of inverse receptances in the neighbourhood of critical speeds

In order to accomplish the first part, it is noted that if a plot is made of the inverse receptance against rotating speed, it is found to be of the general shape indicated in Fig. 1, which in the region of a critical speed resembles a rectangular hyperbola. If, therefore, we have the values of inverse receptance at three speeds ω_1, ω_2, ω_3, where $\omega_3=\omega_2+250$ and $\omega_2=\omega_1+250$, such that the first inverse receptance is positive, whilst the second is negative, or positive and greater than r_1, then a critical speed must lie between ω_1 and ω_2.

The programme is designed to calculate and print out the values of r against ω at intervals of 250 r.p.m. for a range specified by the customer.

As the calculation proceeds a check is made for two consecutive values of r which satisfy $r_n \geqslant 0$, $r_{n+1} < 0$ or $\geqslant r_n$. When two such values are discovered, ω_n, r_n, r_{n+1}, and r_{n+2} are stored, and the calculation proceeds until another set is found, in which case the same procedure applies. When the end of the range is reached, the programme will stop if no such set is found. If the second ω in a set coincides with the end of the range, the range will be extended by 250 r.p.m. The flow diagram for this stage of the programme is shown in Fig. 2.

Having obtained all the possible sets of three, the programme then returns to deal with the first set and uses a hyperbolic approximation to estimate N_{c1} from

$$N_{c1}=\omega_1+\frac{500\, r_1\,(r_2-r_3)}{(r_1r_2-2r_1r_3+r_2r_3)}$$

(This estimate is derived by assuming that the three points do in fact lie on a rectangular hyperbola.)

The corresponding inverse receptance is found and if this is positive (indicating an estimate which is less than the critical) the estimate is increased by 5 r.p.m., if negative, a reduction of 5 r.p.m. is made. The process is repeated until a change of sign of r occurs, which usually happens within two calculations. When this change of sign has happened the previous value of ω is printed and a tabulation made of deflection, change of slope, and shear force for each section of the shaft. These values will not be absolute, since they are multiples of one of the initial unknowns, but they serve to show relative deflections and points of weakness or undue strength in the shaft, which are useful to the designer if the criticals need to be raised or lowered.

The homing procedure works satisfactorily for about 95 per cent of the shafts considered, but in some cases, especially when the shaft has a long overhang, the inverse receptance-speed curve departs so far from hyperbolic form that the estimate is worthless. This can happen in various ways, as shown below :

(1) If $r_3 < r_1$ and $r_2 > 0$ (which implies $r_2 > r_1$), as shown in Fig. 3.

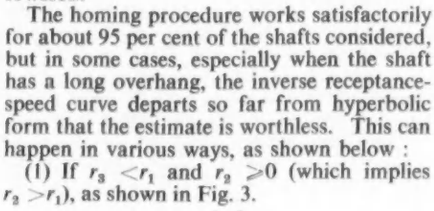


Fig. 3

In this case r_3 is replaced by $(r_2-r_1)/2$. In theory this only confines the estimate E to the range $\omega_1 < E < \omega_1+500$, but in practice

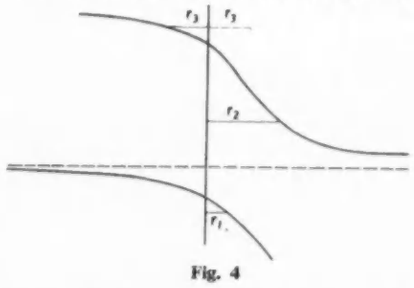


Fig. 4

it usually gives a reasonable estimate. If not, case (2) will usually correct the error. When this has been done a test is made to see if $r_3 < 0$. If so, a second set is formed, defined by

$$\omega_1=\omega_1+250$$
$$r_1=r_2$$
$$r_2=r_3$$
$$r_3=r\,(\omega_1+750)$$

Otherwise no action is taken until the next inverse receptance has been found.

(2) If the estimate lies above the horizontal asymptote as shown in Fig. 4.

Given this estimate the programme would normally find $r(\text{Est.})>0$ and proceed to increase the estimate by 5 r.p.m. as described above. However, a test is made to see if $r(\text{Est.})>r_1$, which will occur only if the estimate lies above the asymptote. If this is the case the estimate is reduced by 35 r.p.m., and the procedure is repeated until an estimate is found which lies below the asymptote. The normal 5 r.p.m. homing procedure then takes over. These various alternatives are here shown in the flow diagram of Fig. 5.

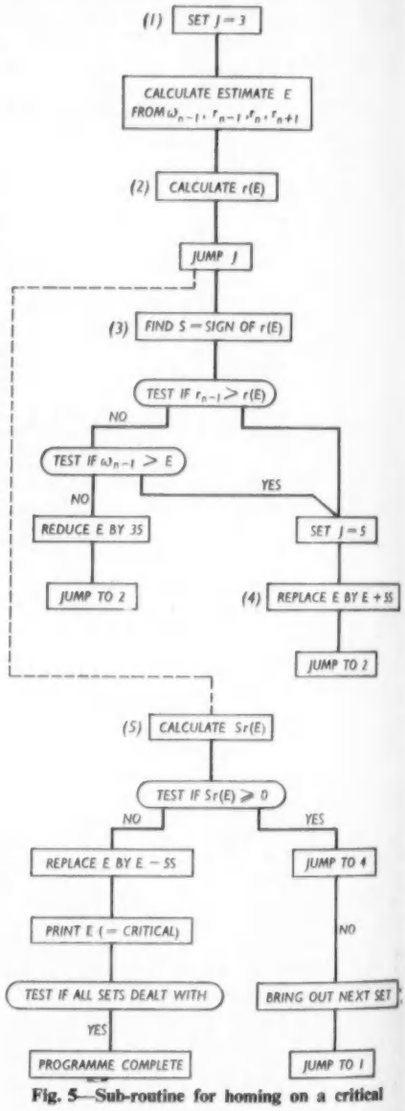


Fig. 5—Sub-routine for homing on a critical

General Comments and Conclusions

A careful analysis of the preceding paragraph will show that various conditions can be envisaged in which a critical might be missed by this searching technique. However they are all of the kind in which two criticals lie very close together, and the results of using an interval of 250 r.p.m. are ambiguous. For instance the condition $r_1>0$, $r_3<r_2<0$ could be a result of either of the inverse receptance-speed curves shown in Fig. 6.

The only solution appears to be a reduction of the interval used when such a condition

is found. This may be predicted by the designer of the shaft or may be deduced from an inspection of the initial tabulation of inverse receptance against speed. It should be mentioned that in all the shafts so far analysed, no case has been found in

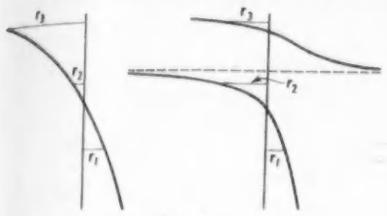


Fig. 6

which the programme did not supply all the required criticals.

The hyperbolic approximation has been found to give an accuracy of 1 r.p.m. in 3000 in most cases investigated, and even when the answer is given to the nearest 5 r.p.m. the fact that an idealised shaft is being considered makes further accuracy of rather doubtful importance. Although double-length floating-point working is used in the recurrence relations and a maximum of eighty sections can be dealt with by the programme, it would appear that rounding errors in the recurrence relations begin to make themselves felt if more than fifty sections are used in the idealised shaft, so that a balance must be struck between errors of representation and errors caused by rounding. The other important factor is time, the length of the calculation being proportional to the number of sections dealt with. For a turbo-shaft of overall length 350in with body diameter 40in, thirty-five to forty sections appear to give the most accurate and economical results.

ACKNOWLEDGMENTS

The author wishes to thank The General Electric Company, Ltd., for permission to publish this article.

The Durability of Concrete Kerbs

By P. J. F. WRIGHT, B.Sc.*

This article summarises some investigations into the resistance of concrete to frost and the durability of kerbs carried out in recent years, mainly by the Road Research Laboratory and the Cement and Concrete Association. The results obtained in these investigations are discussed together with other data.

A ROAD Research Technical Paper[1] dealing with failures in precast concrete kerbs was issued in 1950, and in the same year the British Standard[2] for concrete kerbs was revised. It was believed that the requirements of the latter would reduce the proportion of failures in concrete kerbs, but extensive failures still occur, sometimes after only one year's exposure and sometimes in products which are apparently of good quality concrete.

The most common form of failure appears first as a crazing of the surface of the kerb, the cracks being conspicuously black and sometimes following a distinct pattern (Figs. 1 and 2). Microscopic examination of sections of kerb which have reached this stage has revealed that the cracks penetrate an inch or two into the concrete and generally follow the outlines of particles of coarse aggregate, thus indicating a failure of the bond between coarse aggregate and mortar. The cracks are up to about 0·01in wide and do not contain any apparent deposit or product of chemical reaction. It is believed that as water rises through the cracks it dissolves free lime from the set cement and that on reaching the surface the lime reacts with atmospheric carbon dioxide to form a hard crust of calcium carbonate, which becomes coloured by dirt. The cracking appears to progress steadily until complete disintegration occurs of that part of the kerb which is above the level of the carriageway, the portion below ground remaining relatively undamaged. This type of failure is not limited to any one part of the country nor to any one group of aggregate types. It has not, however, been observed by the Laboratory in hydraulically pressed kerbs.

Several possible causes of the initial cracking have been suggested, but they do not explain all the failures. They are :

(1) Direct frost action on the concrete, the relative immunity of hydraulically pressed kerbs being due to a difference in pore structure. The failures produced in specimens frozen and thawed in laboratory tests, however, do not have the same appearance as those observed in kerbs.

(2) Differential thermal expansion or moisture movement between the coarse aggregate and mortar, the relatively immunity of the buried portion of a kerb being explained by the relatively stable conditions below ground level. Recent work by the Scottish branch of the Building Research Station has shown that certain aggregates exhibit moisture movements large enough to produce such cracking, but this does not explain the immunity of hydraulically pressed kerbs.

(3) Longitudinal compression developed by restrained expansion. This is borne out by observed cases of end splitting of kerbs, but the theory would not explain failures which have occurred where there has been no restraint, as for example that shown in Fig. 3 in an unused kerb taken from a local authority's depot.

A number of investigations have been carried out by different laboratories into the durability of concrete with particular reference to kerbs, and a brief summary of the results is given and has been considered with a view to determining whether any particular factor might be of prime importance in ensuring concrete durability.

SUMMARY OF INVESTIGATIONS INTO CONCRETE DURABILITY

1. *Laboratory Freezing and Thawing Tests on Cubes Carried Out at the Road Research Laboratory.*—From these tests, some of which were reported in "Concrete Roads : Design and Construction,"[3] it was concluded that durability was primarily dependent on the water/cement ratio. It was also shown that for a given water/cement ratio the durability was improved by reducing the cement content, or by using finer gradings. Limestone, and particularly chalk, produced less durable concrete than a flint gravel aggregate, and the use of un-neutralised Vinsol resin or aluminium powder improved the durability of the concrete to a small extent, although no measure was made of any entrained air or gas. However, it has been adequately demonstrated elsewhere[4] that in similar freezing and thawing tests the proper use of air-entrainment can improve the durability of the concrete considerably.

2. *Examination of Kerbs by the Road Research Laboratory and the Cement and Concrete Association.*[1]—Sample kerbs taken from lengths of damaged and undamaged kerbs were tested for crushing strength, water absorption and cement content. Most of the kerbs that had failed appeared to

* Road Research Laboratory, Department of Scientific and Industrial Research.

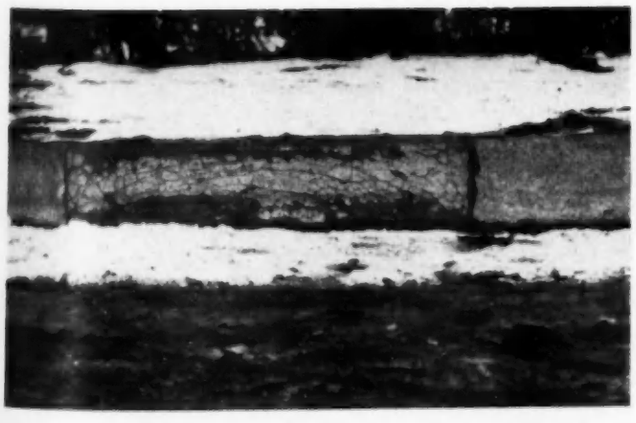


Fig. 1—Typical kerb failure showing pronounced pattern of cracking

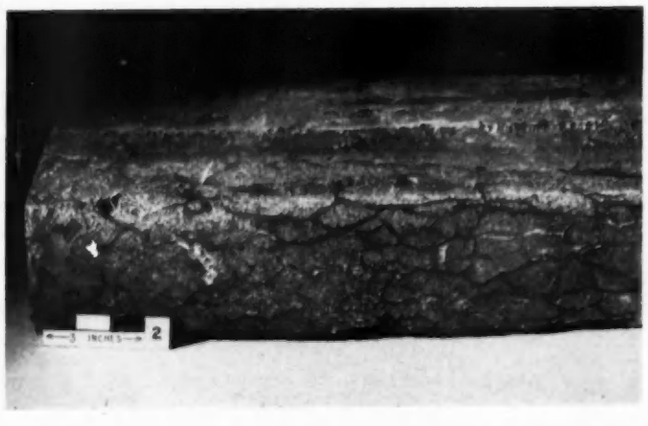


Fig. 2—A failing kerb showing ridges of calcium carbonate deposited over cracks

Technical Contributors Section (*continued*)

Fig. 3—An unused kerb showing early crazing which extended to a depth of about 1in

have been made with a relatively high water/cement ratio. Some correlation was found between the performance of the kerbs and their water absorption after ten minutes.

3. *Experimental Kerbs Laid by the Road Research Laboratory.*—Of 144 laboratory-made kerbs with water/cement ratios ranging from 0·4 to 1·2 laid in Surrey in 1947 even those with the highest water/cement ratio were not in as bad a condition after nine years exposure as were many commercial kerbs after a shorter period. This suggests that the water/cement ratio is not the controlling factor in determining the durability of kerbs. Six of the mixes used contained air-entraining admixtures, but these do not appear to have improved the durability of the kerbs.

Some kerbs laid at Monkton in Ayrshire in 1953 were prepared at a works which had had a number of failures even though the kerbs appeared to be of high quality when examined by normal test procedures. The kerbs were made under controlled conditions with different mixes and using the local dolerite and a flint gravel aggregate ; two batches were made with entrained air. After four years exposure all the kerbs were in a satisfactory condition and there was no appreciable difference between kerbs from the different mixes. Certain batches which had received no curing were slightly inferior, but the difference was too small to justify any conclusion.

4. *Laboratory Freezing and Thawing Tests on Kerbs Carried out by the Cement and Concrete Association.*[5,6]—Samples cut from a range of kerbs were subjected to freezing and thawing cycles and deterioration was assessed by ultrasonic testing and by loss in weight. The principal conclusion was that the durability showed a good correlation with the ten-minute absorption value, but a less good correlation with transverse strength. It was also concluded that the present B.S. limits for absorption are too high to ensure a durable kerb and that the existing method of testing for absorption gives undesirably variable results.

5. *Experimental Kerbs Placed on an Exposure Site in* 1952 *by the British Cast Concrete Federation.*—The kerbs were all made with an aggregate/cement ratio of 1 : 6, but had different water/cement ratios ; two of the mixes contained an air-entraining agent. The kerbs were totally exposed without any restraint and some were placed in shallow trays of water. Kerbs made with water/cement ratios of 0·425 and 0·55 had not been damaged by frost after four winters, while those with a water/cement ratio of 0·65 showed severe frost damage. Kerbs containing an air-entraining agent and having water/cement ratios of 0·475 and 0·62 showed no damage.

6. *Recent Work at the Road Research Laboratory.*—Damaged and undamaged kerbs from three sites were tested in the Laboratory for ultrasonic velocity, transverse strength, crushing strength of sawn and capped cubes, water absorption, and cement content by chemical analysis. The crushing strength and water absorption were determined on specimens cut from the bottom half of the kerbs, which had been below ground level and were apparently undamaged in every case. Kerbs from different sites showed considerable differences in quality, but the differences between damaged and undamaged kerbs from the same site appeared to be small. Thus differences in ultrasonic velocity, strength, or cement content were not necessarily associated with differences in performance. For example, the transverse failing loads of the damaged kerbs ranged from 2900 lb to 6600 lb and those for the sound kerbs ranged from 3400 lb to 6600 lb. The ten-minute absorption figures, however, were 2·4 per cent or less for all the sound kerbs and 2·2 per cent or more for all the damaged kerbs. This is shown diagrammatically in Fig. 4, which includes also the results of tests on kerbs reported in Technical Paper No. 18 and some data obtained on unused hydraulically pressed kerbs.

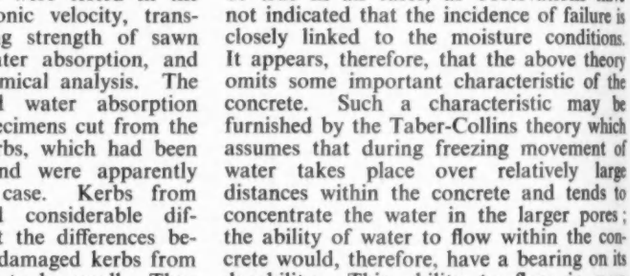


Fig. 4—Distribution of absorption values for sound and damaged kerbs

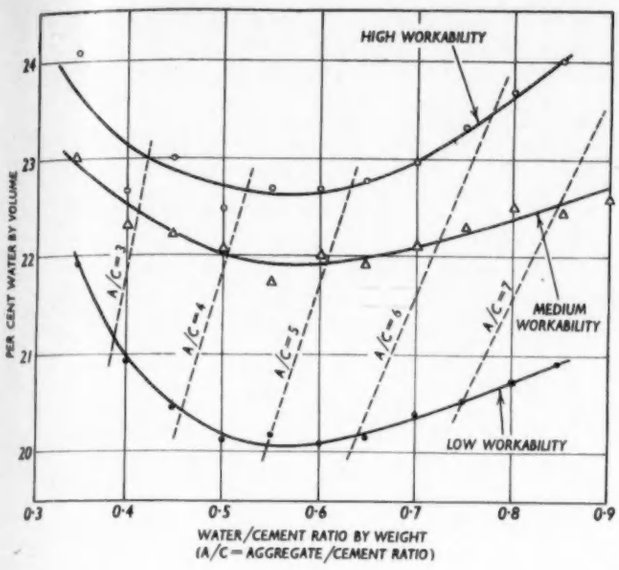
Theories of the Cause of Failure

It is clear from the above results that the durability of concrete kerbs is not dependent solely on the water/cement ratio as was once thought.

Two theories have been projected about the mechanism of frost action in concrete : the Taber-Collins theory[7] and the Powers theory.[8] Powers has considered the problem in great detail and has concluded[9] that any concrete that is exposed to moisture before freezing will be susceptible to frost damage unless it contains entrained air. Later, he states that it is important to have a certain number of air bubbles per cubic centimetre of cement paste and not merely to have the required volume of air space. According to this theory, therefore, the many kerbs that have remained undamaged for many years must either have contained the necessary number of air bubbles in the cement paste through unintentional air-entrainment, or have been insufficiently wet at the time of freezing. The first possibility has not been borne out by the few microscopic examinations made at the Road Research Laboratory ; the second cannot be true in all cases, as observations have not indicated that the incidence of failure is closely linked to the moisture conditions. It appears, therefore, that the above theory omits some important characteristic of the concrete. Such a characteristic may be furnished by the Taber-Collins theory which assumes that during freezing movement of water takes place over relatively large distances within the concrete and tends to concentrate the water in the larger pores ; the ability of water to flow within the concrete would, therefore, have a bearing on its durability. This ability to flow is more likely to be related to the absorption after a short time than after a long time, and this would explain why the ten-minute absorption test appears to give a better indication of the durability than the twenty-four-hour absorption which depends more on the total porosity.

Characteristics of the Concrete in Relation to Durability

Free Water in Freshly Mixed Concrete.—In fresh unhardened concrete a certain amount of water is required to wet the



Crushed rock aggregate of $\frac{3}{4}$in maximum size with 42 per cent passing a $\frac{3}{8}$in sieve

Fig. 5—Proportion of water by volume in various concrete mixes

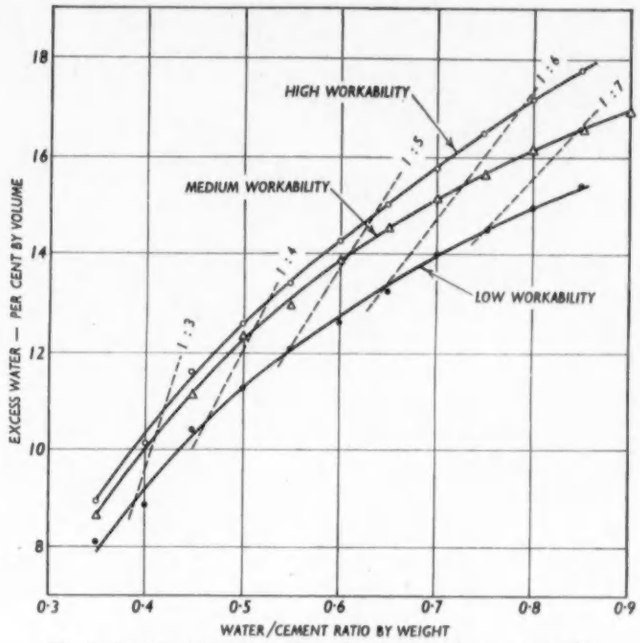


Fig. 6—Results of ten-minute absorption tests on nine concrete mixes

surface of the particles of aggregate and cement, and if a larger quantity of water is used it forms a film of free water around the particles, which initially increases the workability and subsequently forms capillaries which enable water to flow in the hardened concrete. The film thickness may be reduced either by reducing the water content or by increasing the specific surface of the solid materials. Either of these changes will reduce the workability and improve the durability. It can be shown, from data given in Road Note No. 4,[10] that a relatively low workability is necessary to achieve a low water content by volume. The examples shown in Fig. 5 for concrete made with a $\frac{3}{4}$in crushed rock aggregate conforming to grading curve No. 3 were chosen because such materials are commonly used for concrete kerbs, but similar curves are obtained for other materials. The diagram shows that for a given workability the total water content cannot be reduced below a certain figure simply by reducing the water/cement ratio. If the workability is reduced while either the aggregate/cement ratio or the water/cement ratio remains constant the total water content is reduced.

As relatively workable mixes are often used for vibrated concrete kerbs in order to obtain an acceptable finish, it is useful to consider methods of increasing the workability without increasing the permeability. One method is to use a rounded aggregate in place of an angular one. Although not established by the investigations mentioned above, it seems likely that many of the worst cases of failure in concrete kerbs have occurred where flaky aggregates have been used.

Another method would be to entrain air in the concrete ; this improves the workability without increasing the permeability and has been shown to produce more durable concrete.

Relation Between Ten-Minute Absorption and Original Water Content.—As experimental data have suggested that the ten-minute water absorption of kerbs provides a measure of their durability, whereas theoretical considerations have indicated that the original water content may be important, tests have been carried out to examine whether there is any relation between these two factors. Nine different concrete mixes were prepared, including mixes having high, medium and low workability and having aggregate/cement ratios of $3\frac{1}{2}$, $4\frac{1}{2}$ and 6, the materials being the same as those to which Fig. 5 refers. Three 6in cubes were made from each mix and a specimen from each was tested for ten-minute absorption in the standard manner. In Fig. 6 the results are plotted against (i) the water/cement ratio by weight, (ii) the total water content by volume and (iii) the volume of water in excess of that required for hydration of the cement, this being taken as 22 per cent of the weight of cement. The results approximate to a single curve most closely in the third case, which indicates a fairly close relation between the ten-minute absorption and the volume of excess water.

The excess water by volume has been plotted in Fig. 7 against the water/cement ratio for concrete mixes made with the same materials as those used in Fig. 5. As with Fig. 5 similar curves would be obtained with other materials. The diagram shows that to ensure that the excess water content does not exceed a certain value, a mix of high workability will require a lower water/cement ratio than one of low workability. Thus to obtain a durable concrete a mix of high workability would require more cement than that needed to obtain the same strength as a mix of lower workability. For example, it can be shown from Fig. 7 that a mix of high workability with proportions of 1 : $4\frac{1}{2}$/0·55 would have the same strength as a mix of low workability with proportions of 1 : 5/0·55, but in order to have the same excess water content (12 per cent) proportions of 1 : $3\frac{1}{2}$/0·47 would be required for a mix of high workability.

To illustrate whether there is any relation between the proportion of excess water and the frost resistance of concrete, some of the results of the laboratory freezing and thawing tests on cubes carried out at the Road Research Laboratory are plotted in Fig. 8. The index of frost resistance used is the ratio, expressed as a percentage, of the crushing strength at twenty days of cubes subjected to eleven cycles of freezing and thawing, starting at seven days, to that of cubes cured for the same period in water at approximately 62 deg. Fah. The results plotted are those obtained with various mixes made with normal sand and gravel ; mixes in which the grading only was varied are excluded, since the grading would be expected to affect the permeability to some extent and thus to affect the durability without any change in the amount of excess water. While the results in Fig. 8 cannot be said to lie on a single line, a general relation is apparent.

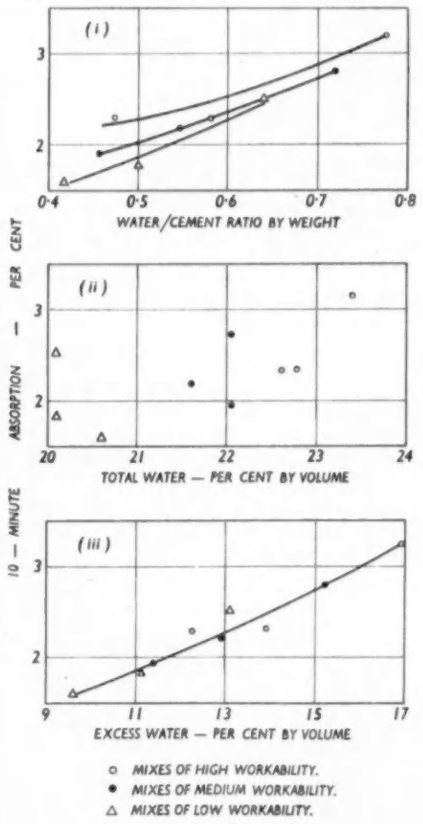


Fig. 7—Relation between water/cement ratio and the amount of water in excess of that required for hydration, for concretes of different workabilities

Technical Contributors Section (*continued*)

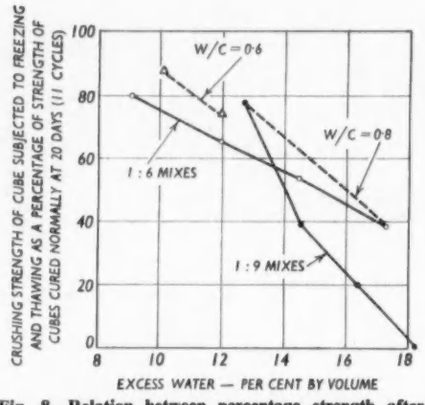


Fig. 8—Relation between percentage strength after eleven cycles of freezing and thawing and excess water content

Tests on Pre-Cast Kerbs and Appropriate Limits of Acceptance

1. *The Absorption Test.*—The investigations examined have shown that the ten-minute absorption test provides a better indication of durability than either the twenty-four-hour absorption test or the transverse test, but that the existing limit of 3 per cent does not ensure a durable product. Fig. 4 shows that the ten-minute absorption figures of the eleven kerbs recently examined at the Road Research Laboratory were 2·4 per cent or less for all the sound kerbs and 2·2 per cent or more for all the damaged kerbs. Of the thirty kerbs quoted in Technical Paper No. 18[1], twenty-seven would follow the same classification. The other three, which gave ten-minute absorption figures of 2·0, 1·9 and 1·9 per cent and showed slight or medium damage, were made with leaner mixes than would normally be used to-day, and it is considered, therefore, that they do not invalidate the above classification.

It appears, therefore, that if the concrete had been of such a quality that all the ten-minute absorption figures were less than 2·2 per cent, a relatively durable kerb might have been expected. A complication arises, however, because these absorptions were measured on specimens taken from kerbs generally two years or more old, whereas an acceptance test would be carried out at an early age, probably in the order of twenty-eight days. From the time when concrete first hardens the porosity gradually decreases as more of the water is used up in hydration of the cement, and from data published by T. C. Powers[11] it is possible to estimate the reduction in porosity which would take place over a period of time. The reduction depends on the water/cement ratio and the following table shows the ratio of porosity at twenty-eight days to that at greater ages for a variety of conditions. It may be assumed that the ratios of absorption would be similar.

Values of Factor K, Being the Ratio of Porosity at Twenty-Eight days to Porosity at Ages of Six or Twenty-Two Months for Concretes of Various Water/Cement Ratios and Cured in Water Under Laboratory conditions

Age (months)	K, Water/cement ratio 0·5	0·6	0·7
6...	1·41	1·35	1·24
22...	2·07	1·62	1·38

As far as the allowable limit of absorption for concrete kerbs is concerned, if the transverse strength is retained with the present limits, the concrete in question is that with a water/cement ratio of 0·6, and a ratio of about 1·6 seems appropriate. If, however, the transverse strength requirement is relaxed in order to encourage the use of air-entrained concrete, it would be more appropriate to consider concrete with a water/cement ratio of 0·7, and the ratio of porosity at twenty-eight days to that at twenty-two months would then be 1·4. These figures, however, are based on the assumption that the concrete is continuously cured in water, whereas the kerbs examined had been exposed to the atmosphere since shortly after manufacture. The result of this exposure to the atmosphere would be a smaller reduction in absorption than that indicated by the above table. Some results obtained by the Research Committee of the Cast Stone and Cast Concrete Products Industry show that the absorption of twenty-two-month-old specimens stored in air was about 1·2 times the absorption of specimens stored in water. Allowing for some relaxation in the transverse strength requirement, it seems, therefore, that the data quoted in the note should in some cases be increased in the ratio 1·4 : 1·2, i.e. about 1·2. On this assumption the suggested limit of 2·2 per cent for the ten-minute absorption should be increased to about 2·6 per cent and the test should be made at the age of twenty-eight days or an appropriate correction applied. As only a very small proportion of kerbs is tested, however, the specified limit must be somewhat lower than 2·6 per cent to ensure that few kerbs will exceed that figure, and a limit of 2·5 per cent is suggested later.

A ten-minute absorption of 2·5 per cent is seen from Fig. 6(*c*) to correspond (at any rate for the type of crushed stone aggregate used for the tests) to an excess water content of 14 per cent. With more rounded aggregates or coarser gradings, however, it is likely that a lower excess water content would be required. Further tests are needed to verify this.

Because the present British Standard method of measuring absorption is tedious and costly it is sometimes neglected and only the transverse strength test is carried out. If a simpler method of test were available, preferably one which did not destroy the kerb, it would probably be used more frequently, Attention is therefore being given to a surface permeability test in which the absorption on a single face of a kerb is measured over the area contained in a 4in square frame fixed to the surface. Until such a test has been proved satisfactory, however, it appears that the water absorption after ten minutes is the best means of assessing the durability of kerbs.

2. *Transverse Strength.*—The existing transverse strength requirement for concrete kerbs was intended primarily to limit the water/cement ratio. This, however, does not in itself determine the durability, and it has been shown that the transverse strength cannot be used to assess durability. It is suggested, therefore, that if the absorption requirement were made more severe, the transverse test need no longer be included as a safeguard of durability. If, however, it is desired to retain the strength test as a measure of the mechanical properties of the kerb, it would be preferable to reduce by about 15 per cent the minimum value permitted, so as to facilitate the use of air-entrained concrete. This would reduce the required load, on a 5in by 10in kerb for example, from 3000 lb to 2500 lb.

3. *Other Factors.*—Some cases have been observed of kerbs that had poor durability although the water absorption was low. For example, the water absorption values for the kerb shown in Fig. 3 were 1·1 per cent at ten minutes and 5·2 per cent at twenty-four hours, and the concrete appeared to be well compacted and very hard. It is possible, therefore, that in some cases some characteristic of an agregate such as its moisture movement makes it unsuitable for use in kerbs. No complete explanation of this case is available, but it was noticeable that the aggregate particles in the kerb shown in Fig. 3 tended to be very flaky (see Fig. 9) and it is suggested that this fact may have been partly responsible for the low durability. A sample of 300 g reclaimed from the kerb ($\frac{1}{2}$in–$\frac{3}{8}$in and $\frac{3}{8}$in–$\frac{1}{4}$in) had a flakiness index of 47 per cent, which is considerably higher than the figure of 35, which is the maximum permitted in B.S. 63 : 1951, "Single Sized Road Stones and Chippings."[12] It seems reasonable, therefore, that a similar requirement might be made for aggregates to be used in concrete kerbs.

Sampling.—The present standard permits the testing of up to three kerbs for the first 1000 linear yards and one further kerb for each further 2000 linear yards. Also, when one of the three specimens fails, two further specimens may be tested and, if both pass, the batch is considered acceptable. Under this system a consignment of 1000 linear yards containing 10 per cent of sub-standard kerbs will be accepted, on the average, in twelve cases out of thirteen. With 20 per cent of sub-standard kerbs the chances of acceptance are three in four.

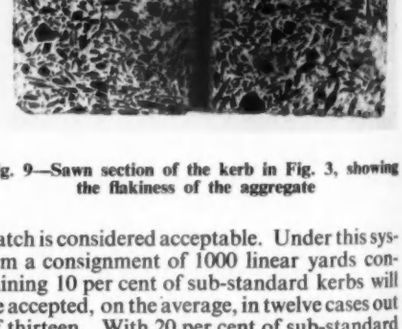


Fig. 9—Sawn section of the kerb in Fig. 3, showing the flakiness of the aggregate

The high probability of accepting some sub-standard kerbs is largely due to the provision for retest in the event of one failure. If this provision is omitted the chance of accepting a consignment with a considerable proportion of sub-standard kerbs is reduced, but the chance of accepting a consignment when there are very few is

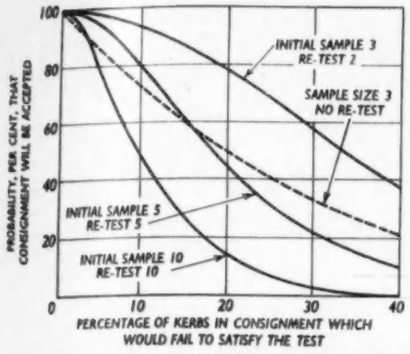

PROBABILITY, PER CENT, THAT CONSIGNMENT WILL BE ACCEPTED
INITIAL SAMPLE 3 RE-TEST 2
SAMPLE SIZE 3 NO RE-TEST
INITIAL SAMPLE 5 RE-TEST 5
INITIAL SAMPLE 10 RE-TEST 10
PERCENTAGE OF KERBS IN CONSIGNMENT WHICH WOULD FAIL TO SATISFY THE TEST

Fig. 10—Probability of accepting consignments of kerbs under various sampling systems

also reduced, as shown in Fig. 10. If, however, the sample size is increased, both for the initial test and the retest, the chance of accepting, say, 20 per cent of sub-standard kerbs is much reduced, whilst consignments with very few below standard are still almost certain to be accepted. As the number of kerbs tested increases, the system becomes increasingly selective[13] and with a sample size of 10 (+10 in the event of retest) the chance of accepting a consignment with 20 per cent defective would be reduced to one in seven. To avoid having to test such a large sample, however, the probability of rejecting unsound kerbs can be increased by adopting a limiting value such that there is a small margin between it and the value separating sound and unsound kerbs. The most acceptable solution is probably obtained by increasing the sample size to 5 (+5 in the event of retest) and reducing the limit of acceptance from the figure of 2·6 per cent, which appears to divide sound from unsound kerbs, to a figure of 2·5 per cent. This represents only a small reduction and a larger one would be preferable, but to propose an acceptance limit to a closer degree of accuracy than the round figure of 2·5 would suggest a degree of precision which the information does not warrant. The likelihood of kerbs being unsatisfactory (i.e having ten-minute absorption values greater than 2·6 per cent) when accepted on this basis depends on the average properties of the concrete and the amount of variation, and may be estimated from the curves in Fig. 11.

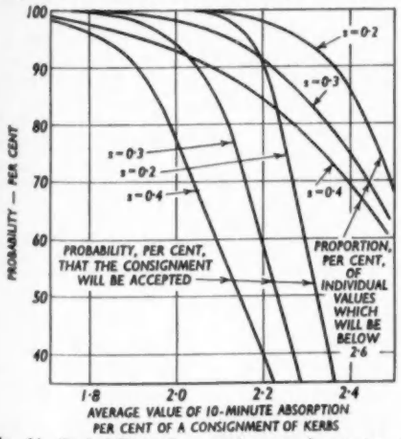

PROBABILITY — PER CENT
s=0·2
s=0·3
s=0·3
s=0·2
s=0·4
s=0·4
PROBABILITY, PER CENT, THAT THE CONSIGNMENT WILL BE ACCEPTED
PROPORTION, PER CENT, OF INDIVIDUAL VALUES WHICH WILL BE BELOW 2·6
AVERAGE VALUE OF 10-MINUTE ABSORPTION PER CENT OF A CONSIGNMENT OF KERBS

Fig. 11—Probability of accepting consignments of kerbs with various average values of ten-minute absorption and standard deviations, s

The data in the Cement and Concrete Association Technical Report No. TRB/231[5] suggest that the standard deviation of individual results is about 0·2 per cent, but the sample kerbs were probably all taken at one time and it is likely that the variation would be rather higher for continued production. If the standard deviation is taken as 0·2 and it is required to ensure a 90 per cent chance of acceptance, it would be necessary to produce an average value of 2·2 per cent, and under these conditions 98 per cent of the kerbs would have values below 2·6 per cent. With a standard deviation of 0·4 per cent the average absorption would have to be reduced to 1·9 per cent. In these conditions 96 per cent of the kerbs would have water absorption values less than 2·6 per cent and might be expected to give good performance.

Conclusions

(1) The best available guide to the durability of a concrete kerb is the ten-minute water absorption test of B.S. 340 : 1950. There is some theoretical justification for requiring a low absorption after a short time which is likely to be related to the rate of absorption, rather than a low absorption after a long period which is likely to be related to the total porosity.

(2) To ensure a durable kerb the limit for the ten-minute absorption test required by B.S.340 should be 2½ per cent at twenty-eight days. The present limit of 3 per cent at any age is too high.

(3) Durability is not dependent primarily on the water/cement ratio of the concrete, and thus the transverse strength, which is largely determined by the water/cement ratio, cannot be expected to give a good indication of durability.

(4) The water absorption after ten minutes appears to be related to the volume of water in the kerb immediately after compaction in excess of that required to hydrate the cement. Thus for vibrated kerbs, in order to obtain low absorption the amount of water used must be low. This will require concrete of relatively low workability irrespective of the cement content, unless a plasticising or air-entraining agent is used.

(5) Low values of absorption can be obtained in vibrated kerbs by the use of air-entrained concrete, but it has sometimes proved difficult to meet the present requirement of the transverse strength test. Thus, if it is desired to retain the strength test as a measure of the mechanical properties of the kerb, the minimum strength should be reduced by about 15 per cent in order to facilitate the use of air-entrained concrete.

(6) The ten-minute absorption of hydraulically pressed kerbs is generally below 2 per cent, indicating that the amount of water remaining in the kerb after pressing is low enough to provide adequate resistance to frost.

(7) It also seems desirable to impose a limitation of 35 on the flakiness index of aggregates used in concrete kerbs.

(8) With the number of kerbs required for test by B.S.340 : 1950 there is a high probability of accepting some sub-standard kerbs. The number required for test should be increased to five ; in the event of one failure, a further five should be tested and all required to pass.

Acknowledgment

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Application of Elliptical Gear Wheels

by HUGH CLAUSEN

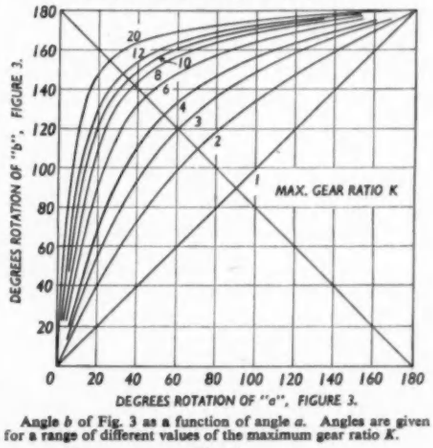
ELLIPTICAL gear wheels have been used for converting uniform into non-uniform motion, and they have been described in various books and journals*. An application of this method of converting from a linear to a very non-linear scale, to give an expanded scale in the middle zone of a centre reading dial, is described below.

Fig. 1 shows the type of functions that can be obtained, over half a revolution of each wheel. They depend on the character of the ellipse as defined by the maximum gear ratio *K*, as shown in Fig. 2.

With each of the wheels pivoted at a focal point of the ellipse, and a link connecting the other two focal points, only one or two teeth at each end of the ellipse are needed to carry over the dead centre. The link does the rest of the driving, as shown in Figs. 2, 3, and 4.

The method of computing the curves as shown on Fig. 1 for any particular maximum gear ratio is given below ; and provided that

* e.g. *Mechanical World*, January, 1960, page 10.



Angle *b* of Fig. 3 as a function of angle *a*. Angles are given for a range of different values of the maximum gear ratio *K*.

Fig. 1

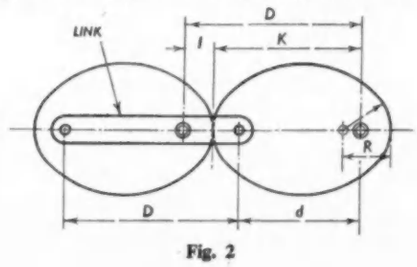


Fig. 2

Technical Contributors Section *(continued)*

Tabulation for working an example :—

Max. ratio K=... ... ... $\frac{K-1}{K+1}$=..., $=Q$=... ... ..., A=... ... ...,

1	2	3	4	5	6	7	8	9	10	11	12
a	$\sin a$	$Q \sin a$	$\cos a$	$Q \cos a$	$\frac{1-(5)}{1-Q\cos a}$	(3)/(6)=$\tan c$	c +	$2c$	$a+2c-b$	$\sin b$	$\frac{\sin b}{\sin a}=k$ $=\frac{db}{da}$

a function of suitable character can be found as one, or a part of one, of these curves, the character of the function can be readily worked out by the tabulation given. The number of points to be calculated for plotting a curve can be greatly reduced by calculating the db/da values, and drawing the tangent to the curve at each point.

Difficulties may arise with high values of K as there will be a step up gear of this ratio

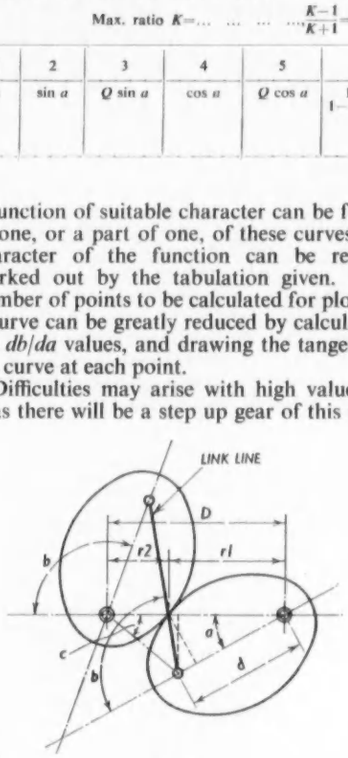


Fig. 3

at one end or the other. This can often be avoided by applying the drive to both elements, through a differential gear; with the driving gear arranged as shown in Fig. 4, equal torques are applied to both elements. This gives a third function X for the driving spindle, intermediate between the other two, a and b of Fig. 3.

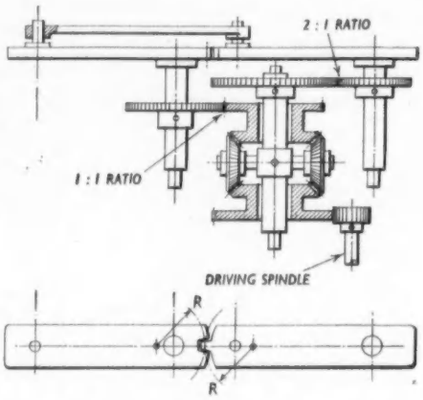
The relations between the three functions are shown in Fig. 5, and Fig. 6 shows the angles a and b plotted as functions of X, the intermediate function.

A wide range of other functions can be obtained from differential combinations of the a and b quantities in different proportions. The dotted lines of Fig. 7 given the character of some of these mixed functions as given by different combinations of the a and b quantities, as $b+a$, $b-a$, and $a-b$.

Calculation of the curves of Fig. 1.

Major axis of ellipse, D=distance between centres.

Maximum gear ratio, up or down, $=K$, see Fig. 2.



Tooth and tooth space as for a pinion of p.c.d. $=2R$, Fig. 2.

Fig. 4

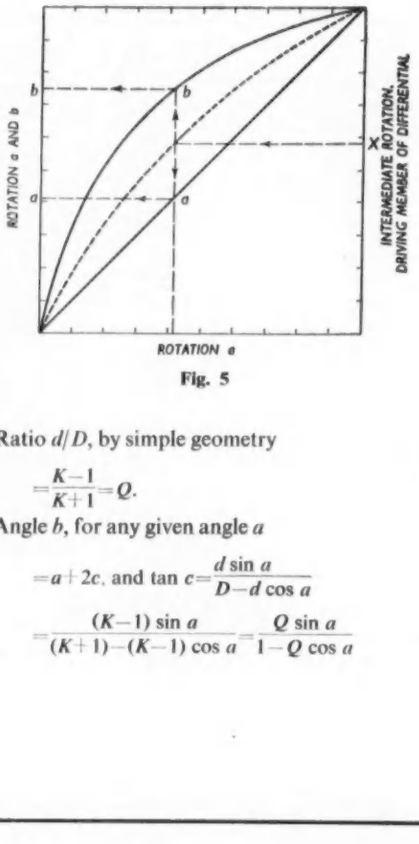


Fig. 5

Ratio d/D, by simple geometry

$$=\frac{K-1}{K+1}=Q.$$

Angle b, for any given angle a

$$=a+2c, \text{ and } \tan c=\frac{d\sin a}{D-d\cos a}$$

$$=\frac{(K-1)\sin a}{(K+1)-(K-1)\cos a}=\frac{Q\sin a}{1-Q\cos a}$$

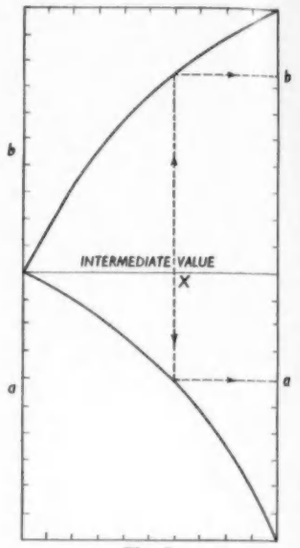


Fig. 6

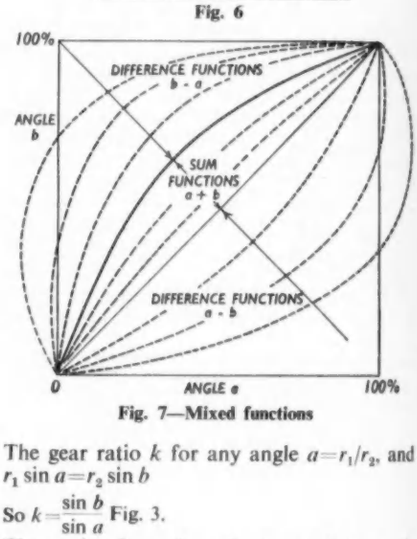


Fig. 7—Mixed functions

The gear ratio k for any angle $a=r_1/r_2$, and $r_1 \sin a=r_2 \sin b$

So $k=\frac{\sin b}{\sin a}$ Fig. 3.

The angle of rotation of a to reach the position of 1 : 1 gear ratio is $\cos^{-1} Q=A$. At this point the major axes are parallel and the minor axes coincident.

The radius of curvature at the ends of the ellipse, R of Figs. 2. and 4, is

$$=\frac{D(1-Q^2)}{2}$$

The minor axis of the ellipse

$$=D\sin A=D\sqrt{1-Q^2}$$

As the curves are symmetrical, angles of a greater than A are not needed.

LETTERS AND LITERATURE

Book Reviews

Proceedings of the Second International Conference on Operational Research. Edited by J. BANBURY and J. MAITLAND. English Universities Press, Ltd., 102, Newgate Street, London, E.C.1. Price 90s.

IT is not possible to present a review in the ordinary sense of this 800 page book, which contains some eighty-five separate papers by as many contributors, but it is possible to give some general impressions.

The first International Conference on Operational Research was held in Oxford in 1957 and subsequently the International Federation of Operational Research Societies was formed. The second Conference, this time under the aegis of I.F.O.R.S., was held in Aix-en-Provence in September, 1960, and it is the proceedings of this Conference that are now published. This Conference was an ambitious affair, lasting a week, and so many papers were accepted by the Committee as being worth presentation that it was impossible to hear all of them, and alternative sessions had to be arranged. Even the present publication is not complete; papers that arrived late and were presented will be printed either in the *Operational Research Quarterly* or in *La Recherche Opérationelle*, published by the French Operational Research Society.

The *Proceedings* are undoubtedly first-class value for those who already practise operational research, and for those who are contemplating using operational research and have the staff qualified to understand the mathematical techniques employed. Whereas in the earlier days of operational research fairly straightforward mathematical and statistical methods were entirely adequate this is becoming less and less true. This does not invalidate the usefulness of operational research; much the same development has taken place in many sections of theory affecting engineering practice, thermodynamics and feedback theory, for example. The day of some of the very advanced techniques discussed has not yet arrived and the value of the *Proceedings* is not so much in giving a view of operational research as it is to-day as in providing a preview of operational research as it will be tomorrow or the day after tomorrow.

The above statement implies a certain amount of criticism. These Conferences are held infrequently—once every three years is the intention—and they assemble many not only from Europe but from America who normally only do meet at these very long intervals. It would seem sensible, therefore, to devote a higher proportion of the time at the Conference to presentation of actual operational research case histories completed and put into effect. There were a few case histories of completed operational research jobs carried out in such varied activities as long-range government planning in India, iron ore unloading, and production allocation in the beet sugar industry. There were also discussion groups, but these did not form a main activity and are reported only in summary form in seventy out of the total 800 pages.

On the methodological side the chief interest was in developments of linear programming, the use of simulation on a wide scale, developments in the use of computers, with particular reference to a common language, and what the French call "Théorie des Graphes," correctly translated as network theory and not theory of graphs. All the papers on the subject were by French operational research workers and very little has been published on the subject in English.

A non-random selection of thoughtful and thought-provoking papers might include: "On Elegance in O.R.," "The Automatic Programming of Simulations," "The Quantitative Effect of Research on National Economic Growth," "Human Performance in the Solution of Logical Problems," "The Assembly Line Problem," "How to State a Production Problem Efficiently," "Control of Spare Parts in the Steel Industry," and "Efficient Measures Against Fraud."

Aerodynamic Capture of Particles. Edited by E. G. RICHARDSON. Pergamon Press, Ltd., Headington Hill Hall, Oxford. Price 50s.

THESE proceedings of a symposium on the collision of small particles or drops carried in a fluid with large obstacles, or with each other, were edited by the late Professor Richardson, who was also responsible for the organisation of the meetings. Those who took part feel that the liveliness of the papers and the vigour of the discussions are in some measure a memorial to a leader in a field of physics and applied mathematics having numerous natural and industrial applications. These include cloud formation and the collision of raindrops, washout of particulate matter (pollutants) by raindrops, laying of mine-dusts by water sprays, impact of water drops or ice crystals on aircraft wings or turbine blades, and filtration.

Following a historical survey by Professor Richardson are four chapters concerned with fundamental aspects and covering dust deposition from a turbulent airstream, a study of computations of capture by spherical obstacles, a photographic examination of the contact of mineral particles and air bubbles in froth flotation, and an account of the role of electric forces in collision processes. It was apparent in this session that the mathematical development of fundamental ideas is now for the most part adequate for consideration of experimental data. Such data were the main topic in the second session. The chapters—on deposition of radioactive gases, size of smoke particles, impact on and damage of rapidly moving surfaces and filtration of airborne particles—contain valuable data, all characterised by care in their collection and skill in their presentation.

The five chapters in the last session are concerned with capture of wettable and non-wettable particles by water sprays and raindrops. These practical topics illustrate how the aerodynamic capture of particles has become in the last decade a true applied science, founded on physical principles and progressing with economy of effort.

Although the discussions after each session are presented tersely, they aid the reader to see whether further work is needed. The proceedings are admirably produced and provide a useful conspectus of the present state of knowledge.

Linear Circuits: Part I—Time-Domain Analysis; Part II—Frequency-Domain Analysis. By RONALD E. SCOTT. Addison-Wesley Publishing Company, 10-15, Chitty Street, London, W.1. Price (each part) 38s.

PROFESSOR Scott contends that a sound knowledge of linear circuit theory is required as a foundation on which all other electrical engineering instruction can be based. This includes the circuit theory of active and non-linear elements, the theory of distributed parameters and signal analysis which are required by the electronics and communication engineer, and the general theory of time varying elements, electrical machines and transducers which are required by the power engineer. To achieve this he builds up the theory of linear circuits as a branch of applied mathematics and he treats electric networks as idealised models amenable to mathematical analysis. He draws a distinction between the analysis of circuits in the time-domain and the frequency-domain, considering the former first. There are four main sections: resistive circuit theory, transients in the time-domain, steady state a.c. circuit theory, transients in the frequency-domain. The first two sections are in Part I (*Time-Domain Analysis*) and the second two in Part II (*Frequency-Domain Analysis*).

The first section deals with the fundamental laws of circuit theory and the methods used for solving one-terminal pair and two-terminal pair networks. The first chapter in this part serves to introduce the circuit variables of currents and voltage and the circuit parameters of resistance, inductance and capacitance, and to state Kirchoff's Laws. Before dealing with the normal methods of solution of networks by means of mesh currents or node voltages, a chapter is inserted giving the basis method of solving for all the branch currents and voltages in an electric network as a topological problem. Topology considerations necessitate the introduction of dummy mesh currents and dummy node voltages which, to the practical engineer, may appear as an artificial complication. Another artificiality adopted for topological reasons is the convention of showing a voltage source with the current *entering* instead of *leaving*. The author in a note draws attention that this may be objected to. In the treatment of the solution of networks the fundamental principle of linearity and the concept of duality are given. A good feature is that as much emphasis is given to the node voltage method of solution as to the mesh current method. The former is becoming of increasing importance in its application to the solution of transistor circuits.

Two full chapters cover respectively one-terminal pair and two-terminal pair resistive networks. In the first Thevenin's Theorem, Norton's Theorem and the Substitution Theorem are given, and methods of network reduction, including $Y-\Delta$ transformation, are discussed. Mention is made of reductions that can be made by the principle of symmetry. The author, to a slight extent, offends this principle in his choice of nomenclature for the $Y-\Delta$ transformation formulae. In the second chapter Bartlett's Bisection Theorem and the Reciprocity Theorem are given, and further network conversions and reductions, including the general star-mesh transformation, are covered. In the treatment

LETTERS AND LITERATURE *(continued)*

of two-terminal pair networks consideration is limited to the *r* and *g* parameters. As the author points out, there are many others. It is arguable that the inclusion of such topics as the analysis of networks by iterative and image parameters, the scattering parameter and reflection and, possibly, greater use of matrix methods would add to the value of the book ; to make space some reductions could be made in the earlier fundamental considerations. The last topic to be covered in this first section is power and energy in resistive circuits. This is an example of the unusual sequence adopted by Professor Scott. The normal course is to consider power after alternating current theory has been covered. The treatment includes the determination of power in terms of mesh currents and node voltages and also its expression in terms of the *r* and *g* parameters.

The second section on transients in the time-domain starts with an introduction to energy storage in electric circuits, bringing out the point that the stimulus-response relationships are no longer constants as they are with resistive networks but are functions of time. It is, however, carefully explained how a great deal of the theory that has been built up for resistive networks can be applied to networks containing inductance and resistance. The next two chapters give the necessary mathematics that is required for the analysis of network time response. The first discusses the processes of differentiation and integration treating them as *time operators*. It also introduces the singularity functions, explaining the unusual but logical notation that has been adopted for the unit step or Heaviside function, the unit impulse or Dirac delta function and the ramp function. The second chapter gives in general terms both the steady-state solution and the transient solution of first and second order differential equations. Making use of the general mathematical results already established so that there is no need to solve any more differential equations, the time response is considered, in turn, of single elements, of *R-L* and *R-C* circuits, and of *L-C* and *R-L-C* circuits. The treatment is comprehensive. It covers the natural behaviour of circuits with initial energy storage and includes the responses due to impulse functions and step functions. Although the treatment is mathematical rather than practical the mathematics is used to the best advantage to explain the physical processes which take place and analogies, such as " exploding a bag of flux-linkages " and " dumping a bucket of charge " are used to help the understanding.

In extending the treatment to the time-domain solution for more general kinds of excitation the relation between pulse excitation and impulse excitation is first of all explained and this leads to the consideration of the Convolution Integral and a number of associated theorems on convolution. This final chapter on transient response includes material not normally covered in elementary circuit theory textbooks and the treatment is at a higher level than the rest of the book. The concluding chapter in this section deals with power and energy in circuits with energy-storage elements, and extends the treatment given in the earlier chapter which deals with resistive circuit elements. There is a short appendix at the end of Part I which discusses transients in more complex circuits. It has been added for completeness to indicate methods that can be used ; it does not go into detail since solutions to more complicated transient network problems are best obtained by means of Laplace transforms.

The third section, which comprises the first half of Part II, *Frequency-Domain Analysis*, deals with steady state alternating current network theory. The introductory chapter explains the method of representing sinusoidal waveforms by means of vectors, or *phasors*, and the next chapter completes the process by explaining the transformation of inductance and capacitance elements into impedance operators, which enables the solution of steady state problems to be carried out algebraically.

Brief mention was made of mutual inductance in Part I when introducing energy storage. Professor Scott suggests that there are two distinct viewpoints to mutual inductance : that of the communication engineer, who considers mutual inductance as one form of coupling in the theory of coupled circuits ; and that of the power engineer, whose concern is with transformers and such considerations as leakage flux and turns ratio. In a full chapter in Part II he presents both approaches and shows their relationship. This is a good feature of the book.

An important subject in frequency-domain analysis is the characterisation of network response as functions of frequency. There are two main techniques : plots of magnitude and phase as functions of frequency—usually to a logarithmic scale—and plots of magnitude and phase in the complex plane. After introducing the concept of complex frequency a clear explanation is given of both processes. The significance of the poles and zeros of driving point and transfer functions is pointed out, showing how they can be interpreted to provide a relationship between steady-state response and transient response. The last chapter in this section follows the previous practice of considering power and energy ; this time it is concerned with alternating current circuits. The treatment is general and not confined to the power frequencies. Active and reactive power, and the method of power calculations with phasors is explained, and the conditions for power matching are covered.

The second half of this volume, the fourth main section, treats transients by frequency-domain methods. Since this includes complex frequency both Fourier and Laplace transforms are covered. A signal analysis approach has been adopted whereby input signals are resolved into their frequency components, the response for each component is found and the total output is obtained by a summation. One chapter deals with the resolution into frequency components. Starting with Fourier's fundamental theorem for the expansion of periodic functions, the Fourier integral and transform are derived as a limiting process of the complex Fourier series. This leads on to the Laplace transform which is considered as a complex Fourier transform where the exponential frequency has been replaced by a complex frequency term, which includes a damping component to ensure convergence. A good account is given of Fourier series including symmetry considerations, numerical methods of Fourier analysis and the Direchlet conditions for convergence. In the same chapter only an introductory explanation is given of the Laplace transform with a short table of transforms.

The second chapter in this section deals methodically with network responses whose excitiation is a Fourier series, a Fourier integral and a Laplace transform. When considering Laplace transforms the initial conditions, energy storage, are taken into account and partial fractions are explained as a method of reducing complex functions to a number of simple standard terms whose inverse transformation can be found from tables.

The following chapter is devoted to the solution of problems by means of Laplace transforms. It shows the transform method of solving transient problems which have previously been covered in Part I in the time-domain, it gives both transient and steady state solutions, showing their relationship ; it covers periodic functions by considering them as repeated transients with delay factors. Driving point and transfer functions are re-examined using transform theory to derive some of their properties. A number of Laplace transforms are given and finally, referring back to theoretical results covered in a previous section, the Laplace transform is applied to convolution and to differential equations. This is a very full and valuable chapter. It provides the theory needed for the application of Laplace transforms to a wide variety of problems. A number of them are treated in earlier parts of the books by other methods. Professor Scott explains that he has done this to bring out a better appreciation of the meaning and merit of transform methods.

The final chapter of the section, the end of the book, is again concerned with power and energy. It treats in turn the power response to a simple sinusoid and a Fourier series, and the energy response to a Fourier integral. The treatment is extended to the power response to random excitation, citing white noise as an example, so that a very brief introduction is given to statistical network theory.

Linear Circuits is one book in two volumes. Although each part is self-contained the pattern of Professor Scott's approach to the subject is best seen by considering the book as a whole. It provides a very comprehensive treatment of elementary linear circuit theory, ranging from basic fundamentals to transform methods. An unusual but logical sequence has been adopted and, purposely, alternative treatments and recapitulations are included. The mathematical nature of the book must not be overstressed. It does not call for any advanced knowledge and no great proficiency is required of the reader as all the equations and workings have been clearly laid out and well explained. Numerical examples are used throughout to illustrate the general principles. In most cases the circuit elements and sources have been given simple integral values—often unity—as opposed to practical values, so that the arithmetical calculations are considerably simplified. The same technique has been adopted for the exercises, a liberal supply of which are contained at the end of each chapter with answers at the end of each volume. Most textbooks use either algebraic symbols to illustrate principles or practical values in worked examples and exercises. The idea of using simple numerical values for both purposes is a good one in a book which sets out to explain basic theory rather than teach practical applications.

The book is very well produced with a good layout and many very clear diagrams.

Deserving of special mention are the excellent summaries at the end of each chapter. They contain, either diagrammatically, in tabular form, or by means of equations with the minimum of text, all the main results established in that particular chapter. They are followed by a list of references appropriate to the chapter with a short introductory commentary. The book has been planned for introductory courses in electrical engineering. Although there will in this country probably be very few courses of instruction that follow the sequence adopted in the two parts of this book, it is recommended to both instructors and instructed. It is well and interestingly written. With its summaries it constitutes a good elementary reference book. Through its somewhat unusual approach to the subject and its clear and detailed account of the underlying basic principles it provides a good insight into fundamentals that are often given a cursory treatment or taken for granted in the important subject of linear circuit theory.

Books of Reference

Interavia ABC, 1961. World Directory of Aviation and Astronautics. Interavia Great Britain, 149, Fleet Street, London, E.C.4. Price 80s.—The ninth edition of *Interavia ABC* contains 25,000 entries (compared with 20000 in 1960), amounting to $0{\cdot}5 \times 10^6$ lines of information. The editors have, therefore, omitted those entities which have refrained from confirming their continued existence. The general system and arrangement remain as previously.

Bulletin of the Provisional International Computation Centre. No. 10-11 (*July-October*, 1960). Rome : Provisional International Computation Centre, Palazzo degli Uffici, Zona dell' E.U.R. Free to interested organisations and individuals.—The current issue of the *Bulletin of the Provisional International Computation Centre* contains a report on the fifth meeting of the ICC Preparatory Committee, as well as an account of the International PICC Symposium held in Rome during the period September 20 to 24, 1960. Other articles include a note on the Seminar on Codes for Reactor Computations (Vienna, April 1960), a study of coffee production in Brazil, Soviet Computer Technology in 1959, and an international list of computation laboratories.

Coal Tar Fuels. Second edition. Editor, W. H. Huxtable. Association of Tar Distillers, 9, Harley Street, London, W.1. Price 21s.—The first edition of *Coal Tar Fuels* was published in August, 1944, and since then the book has been wholly rewritten. Its first chapter describes briefly the production of coal tar in the coal carbonisation process, and then surveys generally the technique of coal tar distillation, and finally shows how the different coal tar fuels are prepared. The second chapter concerns the composition and properties of the fuels, and emphasises particularly the importance of the carbon/hydrogen ratio and low sulphur content. Chapter three deals with the combustion process, and shows the theoretical amounts of air required for combustion of coal tar fuels, and the products resulting. The fourth chapter covers the design of equipment for storage and handling ; the design of heating arrangements for coal tar fuel storage tanks ; the design of pipelines for coal tar fuels ; and the design of flow heaters. Several new nomograms have been included in this section. Some of the many types of burners, pumps, valves, heaters and other auxiliary plant and equipment recommended are described in chapter five. In the final chapter on " Applications," the suitability of coal tar fuels for open-hearth furnaces, forging and rolling furnaces, flame tempering, rotary furnaces, boiler plant, central heating plant, gas turbines, and glass-making furnaces, is demonstrated.

Books Received

Railways. By George Cameron Allen. Basil Blackwell, 49, Broad Street, Oxford. Price 8s. 6d.

Spring Design. By W. R. Berry. Emmott and Co., Ltd., 31, King Street West, Manchester, 3. Price 40s.

Nigel Gresley : Locomotive Engineer. By F.A.S. Brown. Ian Allen, Ltd., Craven House, Hampton Court, Surrey. Price 35s.

The Elements of Heat Flow. By D. A. Wrangham. Chatto and Windus, Ltd., 40/42, William IV Street, London, W.C.2. Price 70s.

Textures in Metal Sheets. By F. A. Underwood. Macdonald and Co., (Publishers) Ltd., 16, Maddox Street, London, W.1. Price 28s.

Directory of Shipowners, Shipbuilders and Marine Engineers 1961. Tothill Press, Ltd., 33, Tothill Street, Westminster, S.W.1. Price 60s.

Engineering Mechanics Statics. By Irving H. Shames. Prentice-Hall International Inc., 28, Welbeck, Street, London, W.1. Price 30s.

Circuit Analysis. By Elias M. Sabbagh. The Ronald Press Company, 15 East 26th Street, New York 10, N.Y. Price 8.75 dollars.

Combustion Engineers' Handbook. Edited by L. J. Fisher. George Newnes, Ltd., Tower House, Southampton Street, London, W.C.2. Price 30s.

Natural Perspective. By James Last. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 21s.

Physical Chemistry. Second Revised Edition. By E. A. Moelwyn-Hughes. Pergamon Press, Ltd., Headington Hill Hall, Oxford. Price 84s.

A Modern Russian Reader for Technical College Students. Edited by N. S. Fudel. Pergamon Press Ltd., Headington Hill Hall, Oxford. Price 35s.

Technical Writing Techniques for Engineers. By Joseph Racker. Prentice-Hall International Inc., 28, Welbeck Street, London, W.1. Price 45s.

Engineering Thermodynamics. By Newman A. Hall and Warren E. Ibele. Prentice-Hall International Inc., 28, Welbeck Street, London, W.1. Price 63s.

Progress in Dielectrics. Vol. III. Edited by J. B. Birks and J. Hart. Heywood and Co., Ltd., Carlton House, Great Queen Street, London, W.C.2. Price 63s.

Nondestructive Testing. By Warren J. McGonnagle. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 116s. 6d.

Civil Engineering Reference Book. Second Edition. Volumes I to IV. Edited by J. Comrie. Butterworths, 4 and 5, Bell Yard, London, W.C.2. Price 357s. for four volumes.

Newnes Electrical Pocket Book. Fifteenth Edition. Edited by E. A. Reeves. George Newnes, Ltd., Tower House, Southampton Street, Strand, London W.C.2. Price 10s. 6d.

Weight-Strength Analysis of Aircraft Structures. Second Edition. By F. R. Shanley. Dover Publications, Inc., 180, Varick Street, New York, 14, New York. Price 2.45 dollars.

Graded Exercises in Technical Drawing for Secondary Schools. (Teachers' Book). By W. G. Beetles. Hutchinson Educational, Ltd., 178-202, Great Portland Street, London, W.1. Price 15s.

Embrittlement by Liquid Metals. By W. Rostoker, J. M. McCaughey and H. Markus. Reinhold Publishing Corporation, New York ; Messrs. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 64s.

Electrical Trades Directory: The Electrical Journal Blue Book 1961. Seventy-Seventh Edition. Benn Brothers, Ltd., Bouverie House, 154, Fleet Street, London, E.C.4. Price 70s.

Technical Data on Fuel. Sixth Edition. Edited by H. M. Spiers. The British National Committee, World Power Conference, 201, Grand Buildings, Trafalgar Square, London, W.C.2. Price 60s.

The Design of Cylindrical Shell Roofs. Second edition, revised and enlarged. By J. E. Gibson and W. T. Marshall. E. and F. N. Spon, Ltd., 22, Henrietta Street, Strand, W.C.2. Price 52s. 6d.

Case Studies in Electromagnetism : Problems with Solutions. By Hermann A. Haus and John P. Penhune. John Wiley and Sons, Ltd., Gordon House, Greencoat Place, London, S.W.1. Price 52s.

Lines Waves and Antennas: the Transmission of Electric Energy. By Robert Grover Brown, Robert A. Sharpe and William Lewis Hughes. The Ronald Press Company, 15 East 26th Street, New York, 10, N.Y. Price 10.00 dollars.

From Theory to Practice in Soil Mechanics. Selections from the writings of Karl Terzaghi. Prepared by L. Bjerrum, A. Casagrande, R. B. Peck and A. W. Skempton. John Wiley and Sons, Ltd., Gordon House, Greencoat Place, London, S.W.1. Price 96s.

OBITUARY

J. W. RYDE, F.Inst.P., F.R.S.

We have learned with regret that John Walter Ryde, F.Inst.P., F.R.S., the chief scientist of the Hirst Research Centre of the G.E.C., died on May 15 at the age of 63.

John Ryde was educated at St. Paul's School and the City and Guilds Technical College, Finsbury, where he studied under Professor Sylvanus Thompson. Later in the first World War he served with the Royal Engineers. On demobilisation in 1919 he joined the newly established Research Laboratories of The General Electric Company, Ltd. as a physicist, and was at once a leading member of the scientific staff. His many and varied early research studies included pure spectroscopy, the gaseous electrical discharge and thermionics. His work on the scattering of light, first applied in the 1920's to optical diffusing media in glasses, was developed by him during the second World War to classic studies of the attenuation and the radar echoes produced by meteorological phenomena at centimetre wavelengths. He made significant contributions to the development of electrical discharge lamps, luminescent materials and optical projection systems. His wartime researches included velocity modulation tubes and crystal valves for microwave mixer devices, and he also worked on the " FIDO " fog dispersal system. To design, in his leisure hours, a pocket illumination chart for use in the Services was typical of him.

Mr. Ryde was elected a Fellow of the Royal Society in 1948, " distinguished in his contributions to pure and applied physics." He was appointed Chief Physicist at the G.E.C. Research Laboratories in 1950 and Chief Scientist in 1953. In recent years he had overall responsibility for the programmes of pure scientific research of the G.E.C.

Ryde's knowledge and interests were very broad. He was a Member of the Royal Institution of Great Britain since 1935 and Chairman of the Davy Faraday Laboratory Committee of the Institution since 1951. He had also served on the Board of Managers of the Institution. He was a Fellow of the Institute of Physics and of the Royal Astronomical Society, and a Member of the Geological Association, the Wiltshire Archaeological Society and the Athenaeum.

In all his work his great ability and perseverance were allied with brilliant insight and inspiration. His colleagues will always remember his patient readiness to discuss and assess the problems of the day and his helpful elucidation of critical experiments, often elegant in their simplicity, which he designed to solve them.

JAMES NEWSON

When Mr. James Newson retired in April, 1957, at the age of eighty-three we were happy to place on record the fact that he had completed no less than seventy years of continuous service with George Reveirs, Ltd., at that time printers of The Engineer. Now, sadly, we have learned that Jimmy Newson died on May 16 after four years of active retirement, following a lifetime of service for The Engineer.

He joined George Reveirs, Ltd. in March, 1887, as a boy reader and a year later he started a seven-year apprenticeship as a compositor. His apprenticeship completed, his job was type-setting for The Engineer which was done by hand until 1911 when the " Monotype " system was installed, and Mr. Newson became Reveirs' first keyboard operator. We shall long cherish the memory of his proud record of craftsmanship.

Grouting: Clay Based and Chemical

By J. T. LEONARD

Grouting connotes various processes some of which have been practised for many years, such as the filling of fissures in rock with mixtures having cement as base. Grouting of alluvial deposits by injection of colloidal grout based on clay or straight chemicals, however, is a more recent development in civil engineering and it is these types of grout and their properties which are reviewed below.

ALL grouts are applied to stabilise a material, to make it impermeable, or to increase the strength of a soil or rock. Also, grouts may be used as an aid in construction and thus be considered impermanent, or used as a permanent and necessary part of a project. The particular conditions of a site determine the properties of the grout to be used and hence its formulation. However, the first requirement of a grout relates to particle size ; thus must be smaller than the void to be filled. A necessary relationship between the size of the voids to be grouted and the size of the particles in the grout has been found in practice. This relationship is defined as the ratio of the 15 per cent size of the formation being grouted to the 85 per cent size of the grout. The ratio is thus determined by the equation :

$$\frac{D_{15}}{d_{85}} > N$$

The values of N are dimensionless and those between 5 and 20 have been proposed for grouts depending on local conditions.

Clay particles are small, and there is a preponderance of particles smaller than 0·002mm. A representative analysis of common clay is given as :

Clay (particle ≤0·002mm)	50 per cent
Silt (particle 0·002–0·05)	43 per cent
Fine sand (particle 0·05–0·25) ...	6 per cent
Liquid limit	63 per cent
Plastic limit	23 per cent

With different clays the clay fraction varies from 30 to 70 per cent of the dry weight. The plastic state, when the moisture content is above 23 per cent, is the state of mobility, and the clay will yield under pressure.

The use of local natural deposits of clay is often possible as a result of recent advances in the techniques of conditioning natural clay. Where the effective size of the alluvial particles permit, a small quantity of cement is usually added to a grout to impart greater strength. However, chemicals alone can be used to provide a degree of stability.

The grouts are applied under pressure, the slurries or chemical fluids being pumped into the ground with sleeved injection tubes. Some injections commence at the bottom of a drill-hole and continue at predetermined stages working upwards towards the surface, while with others the injection begins as the pipes are driven and continue, with a second solution, as the pipes are withdrawn. The pressures used vary, but that of 150 per cent of the maximum hydrostatic head in the hole plus allowances for pipe friction is a particular example.

A suspension of pure cement, a binary mixture of cement and clay, and ternary mixtures of cement, clay and sand have all been used. Of later times, and to allow greater penetration of the grout, colloidal dispersions were developed. When the voids to be filled are very small and require the particle size of the grout to be less than 0·2mm, the practice to-day is to use a colloidal suspension of chemically stabilised clay, chemical fluids that are true solutions and viscous liquids, and recent investigations suggest the use of organic polymers.

Clay Structure

When speaking of clay, the specific reference is usually to those particles with a diameter less than 0·002mm. This particle size range takes in what is known as clay minerals which are, by and large, the hydrous alumino-silicates. Other substances, however, fall within the range such as the non-clay minerals quartz, calcite, iron oxide, and the alteration products of numerous minerals. The clay minerals are broadly classified as kaolin, illite, and montmorillonite. The complexity of clay minerals is simplified by considering the minerals as composed of cations (positive ions) such as Si^{4+}, Al^{3+}, Mg^{2+}, Ca^{2+}, Na^{+}, K^{+}, H^{+}, and anions (negative ions) such as O^{2-}, and $(OH)^{-}$, with a structure where the anions are closely packed, forming a unit with the particle itself, and the cations are interspaced with the anions. The cations can be interchanged or detached from the particle. It has been found convenient to break down the structure into co-ordinated groups of anions around particular cations which are called co-ordinated polyhedra. In clay minerals these arrangements usually occur as tetrahedra (silica), and octahedra (alumina). Sheets are built up of these arrangements, and other element substitutions occur within this general framework.

In the kaolin group the structure consists of a double layer formed from a partially dehydrated gibbsite ($Al_2O_3 \cdot 3H_2O$) sheet sharing oxygen with a silica sheet. The double sheet is electrically neutral ; consequently there is no join of one double layer to the next in the absence of strong bonds. Structurally the montmorillonites comprise a triple sheet, a dehydrated gibbsite sandwich between two silica sheets with which it shares oxygen ions. Strong ionic bonds bind these sheets together. The exterior character of the mineral is undisturbed when Al, Fe, and Mg replace each other within the structure of these sheets of hydrates of aluminium and magnesium. The greater area of broken edges, however, and resultant unsaturated bonds account for the much higher base exchange capacity of this group as compared with the kaolin type of minerals. The illite group of minerals, though extremely varied in composition, is also a three layered structure. The exchange properties lie between the kaolin and montmorillonite types.

A variation in the base exchange capacity of the various minerals is effected by the particle size. The smaller the particle size the greater the surface area and hence the greater the exchange capacity. The main factor, however, in base exchange by these clays is the unsaturated electrical forces occurring along the broken edges of the crystals. The permeability of fine grained soils can be very much affected by the nature of the exchangeable ions. Other properties of a soil besides permeability are also dependent on these ions, and by base exchange reactions the properties can be altered. A sodium soil by being changed to the calcium form and thus made less compressible is an example of property change by base exchange.

Fig. 2—In this tunnel beneath a dam, the radial tubes for back grouting together with the second lift of the plug are shown

Preparation of Grout

The properties most sought for in clay grouting are particle size, crystal expansion, and thixotropy. Some fluid substances increase in viscosity when left standing, but with stirring or shaking they return to their original viscosity. A grout is thixotropic when there is a rate of change of viscosity depending only on time. Thixotropy results, according to Skempton and Northey, from the gradual rearrangement of the particles,

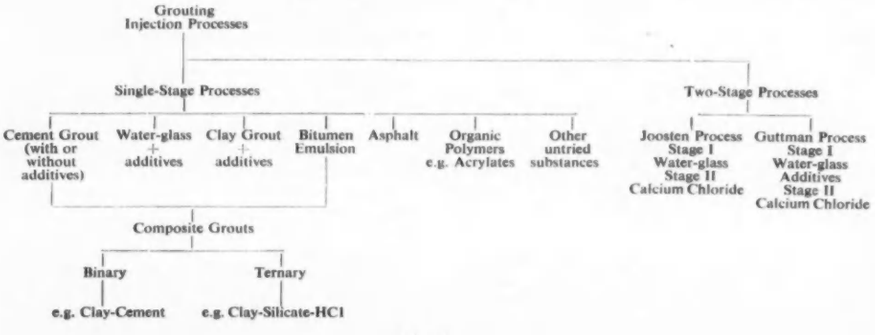


Fig. 1

under the action of the bonding forces, into positions of increasing mechanical stability. This characteristic of a grout assists in the limitation of its own travel and in its thickening after it is pumped in.

Relative proportions, method and mix design vary with the purpose of the grout. A great deal of craft knowledge is also involved since mix is not one of simple proportions but according to the strength required, pumping limitations, and segregation control. In general, the first stage is to prepare a stable suspension, and the second is the addition of a metallic salt like sodium sulphate ($Na_2SO_4 \cdot 10\ H_2O$) to cause flocculation of the suspension after it is injected into the ground. The third stage is the adjustment of the properties of the reagents so that the volume of the clay in the flocculation is the maximum, and that the voids in the soil can be completely filled.

Initially a dense clay grout is prepared to which is added undiluted sodium silicate (Na_2SiO_3) in the proportion of 250 c.c. to each 750 c.c. of clay mixture. The requisite quantities of reagents are then added and the settling time established for each separate mixture. It may be necessary to prepare several grouts in order to accommodate changes in the soil formation. The cohesive strength of the grout is generally determined on the basis of the grout as mixed in the laboratory or in the field. This computation neglects the loss of excess water and resultant increase in strength which invariably occurs during injection.

Although grout proportions are best expressed on a weight basis, a loose volume basis is not uncommon. On this volume basis, and in the case of clay/cement, the loose volume of clay varies between one and twelve times the loose volume of cement. However, for grouting sands, silts and clays, soil volume of between four and six times the loose volume of cement are most common. The volume of water used varies between wide limits, being anything from 3 to 10 cubic feet of water to 1 to 4 (by loose volume) of clay/cement grout.

Under normal working pressures the volume, as mixed, of the grout diminishes by something like 35 to 50 per cent. The amount of water driven off increases with the pressure and the length of time the pressure is maintained. In the case of straight cement grouts and other clay based grouts, chemical compounds are mixed in as additives to act as plasticisers and retarding agents, stabilisers and flocculants. The consistency of the grout is, in general, checked by the relative ease with which it is pumped (i.e. its viscosity) by means of a standard piece of equipment known as a Marsh funnel.

Fig. 3—With the standpipes in pairs, the soft material behind the lining is being flushed out at low pressure

Fig. 4—High pressure grouting machinery of the type generally in use

Grout Quality

All grouts may be said to flocculate eventually, at least to some extent, but the final result can be a definitely segregated deposit. Segregated deposits have a low *Vc/Vs* ratio ; they are only slightly rigid, and are not thixotropic. When flocculants are added prior to the injection of the grout, there is an agglomeration of particles of all sizes and a near enough homogeneous deposit results. Such a deposit has a high *Vc/Vs* ratio and is rigid. The thixotropy of a grout is governed by the clay type and on the ability of the grout to flocculate into a gel whose *Vc/Vs* ratio is equal to one. The corollary, however, is not true. All grouts with a high *Vc/Vs* ratio are not thixotropic. Experience indicates that the *Vc/Vs* ratio and rigidity are directly proportional to the density of the grout. Density, viscosity and thixotropy determine the quality of the grout.

Additives

The techniques of conditioning natural clays allow local deposits to be used. Experience indicates, however, that sodium, potassium, and lithium clays possess the most satisfactory qualities. Most clays require stabilisation with chemicals, and the compounds commonly used to stabilise (the term peptise is also used) clay grouts are potassium nitrate (KNO_3), sodium aluminate ($NaAlO_2$), potassium carbonate (K_2CO_3), sodium silicate (Na_2SiO_3), lithium carbonate (Li_2CO_3), and sodium hydroxide (NaOH). The quantities of stabilisers used are very small, being of the order of 0·25 to 5 per cent of the clay weight.

Waterglass is commonly added to clay grouts to reduce the viscosity and increase the thixotropy, though modified lignosulphonates are added to clay—chemical grouts to lower both the viscosity and gelation. Calcium lignosulphonate in a cement grout acts as a plasticiser and allows a reduction of the water/cement ratio and a retardation of the setting of the concrete when the grout is applied to preplaced, coarser aggregates of concrete. Again, powder aluminium mixed with this grout facilitates expansion.

Flocculation of a grout is important, its chief function being reduction and control of segregation. Most of the flocculants used are salts of sulphuric and hydrochloric acid, such as the sulphate of sodium, copper, iron, and aluminium, and calcium chloride. Other flocculants are tripolyphosphate and hexametaphosphate, and a yet more recent one from the U.S.A. is an acrylamide polymer. When sodium silicate is the stabiliser, hydrochloric acid and sodium aluminate and other grouting reagents are used. The quantities involved in the case of flocculants are even smaller than those of stabilisers.

Chemical Solutions

Whatever the grout composition, there is some field of application. It is in fulfilling the different requirements that the various grouts arise. Chemical grouts based on a silicate have become known ; yet sometimes the word " silicate " is interchanged with the word " chemical " tending to imply the existence of only one grout. Chrome-lignins are other chemical grouts, and still others are based on polymers.

Chemical grouts are sometimes used as aids in construction where the only function of the grout is to stabilise the soil in an excavation, or to stabilise sands during tunnelling. One such grout is a mixture of dilute sodium silicate and a dilute solution of sodium bicarbonate. Applied as a one-shot injection, the resulting gel is weak and lasts only a few weeks, after which the gel starts to deteriorate. However, the object has been obtained in that time, and strong gels not only stabilise but make the digging more difficult. Permanent gelification is obtained by injecting dilute sodium silicate and two reagents, a small amount of hydrochloric acid and copper sulphate.

Two-stage or single-stage processes are commonly in use, though the two-stage, a petrification process, with a small radius of action, requires a large number of boreholes and a corresponding increase in cost. When sodium silicate and calcium chloride are used in the two-stage process, the reaction in the ground is instantaneous, and an insoluble crystalline type solid is formed. In consequence, granular material solidified in this fashion becomes hard and strong enough to serve as a foundation. Other salt solutions such as magnesium chloride, aluminium sulphate, and carbon dioxide have been used in the two-shot process, but it appears that

calcium chloride solution is favoured as generally most satisfactory and economical.

The simultaneous injection of two premixed chemicals is the single-stage, or one-shot process. A mix of two fluids, the process results in gelification. Sodium silicate and a reagent produce a homogeneous gel after a predetermined time which allows for injection of the grout and its dispersion in the ground. The proportions can be adjusted to give a setting time varying from a few minutes to several hours. The reagents most commonly used are hydrochloric acid, sodium aluminate, and calcium chloride. Sometimes two reagents are used, in which case the second reagent is a salt of a strong acid, such as copper or iron sulphate. With this process only a limited number of boreholes are required, there being a more complete penetration and a wider radius of grouting. Again, pumping equipment is less than is the case in the two-stage process.

The gelification obtained with the one-shot process is not as strong as that resulting from the two-shot method. However, high strength is not usually the primary object of grouting where chemicals are used, more often than not the grouts are used to stabilise a material or make it impermeable. In general, the higher the percentage of silicate used the higher is the strength of solidified sands.

A two-shot process has been used in Britain in tunnel driving. The first shot was injected as the pipes were driven into the ground, and comprised sodium silicate and sodium carbonate. The second shot, calcium chloride, was given as the pipes were withdrawn. Where considerable strength is required, this process is probably the best known, and its usefulness in underpinning work, and tunnelling in sands and gravel goes unquestioned.

A true solution can penetrate wherever water can. An interesting case of a true solution grout is that of chrome-lignin used at the Heart Butte dam, U.S.A. The object here was to stop the leaks in the construction joints in the outlet works of this earth-filled dam. Municipal authorities stipulate the permissible concentration of hexavalent chrome in rivers and waterways, and it is recorded that the maximum concentration in the stilling basins was 4 p.p.m., this occurring at the end of the grouting operations. Downstream by ½ mile the concentration was less than 0·05 p.p.m., a figure that is taken as "negative." The formulation from lignin, sodium dichromate, water, and ferric chloride as a catalyst required one or two hours to gel at 40 deg. Fah.

In chemical grouting operations the insoluble products which stabilise the soils or form impermeable curtains are formed from solutions, and the reactions are either metathetical precipitation or polymerisation. Further work is expected to see the extended use of polymers because of the great advantage of low viscosity, the small size of the monomer in solution, and low handling costs. Research in this country places great expectations on water soluble organic polymers.

AMMONIA AND NITROGEN PLANTS AT MILFORD HAVEN.—Work is expected to begin shortly on an ammonia plant which is to be built on a 5-acre site, adjacent to the Esso refinery at Milford Haven, for a joint company formed by the Esso Petroleum Company, Ltd., and Fisons, Ltd. The new plant is designed to produce 150,000 tons of ammonia a year. On a 40-acre site near the ammonia plant Fisons, Ltd., plans to construct a plant to produce nitrogen products, for the fertiliser and chemical industries, from ammonia supplied by pipeline from the joint company's plant. It is expected that both plants will be commissioned by the spring of 1964.

Military Engineering

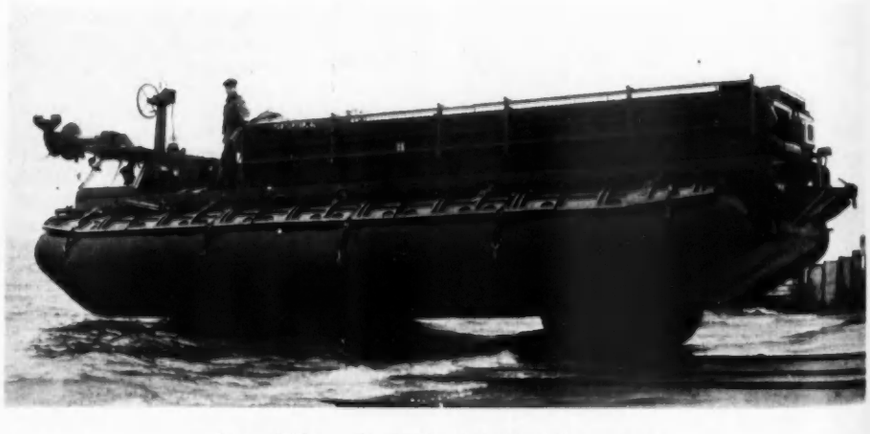
The Military Engineering Experimental Establishment held last week its first Open Day, which provided a glimpse of some new equipment developed mainly for the Royal Engineers.

THE Military Engineering Experimental Establishment at Christchurch, Hampshire, had its origins in the experimental work on tank bridging began there towards the end of the First World War. Bridging still forms a significant part of the work of the Establishment and its director is Sir Donald Bailey, who gave his name to the very successful bridge developed during the Second World War. However, since the end of that conflict the Establishment also became responsible for other types of equipment and it was then that it assumed its present name, instead of its earlier designation of Experimental Bridging Establishment.

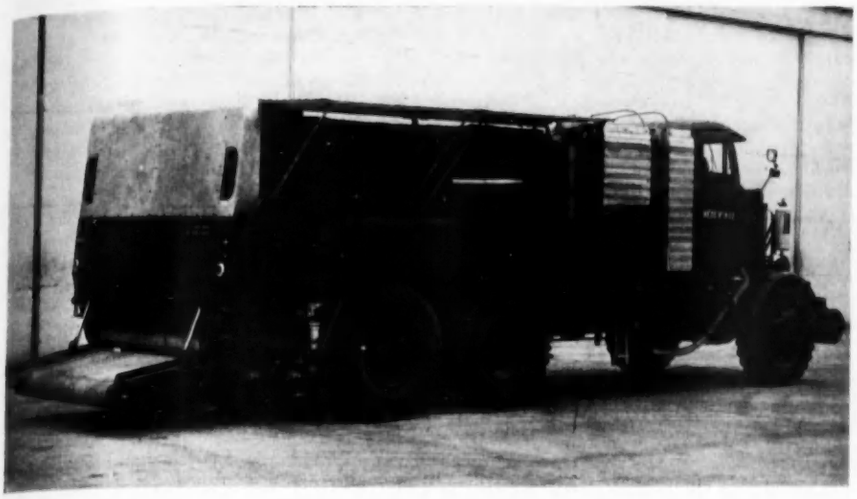
The Gillois-E.W.K. amphibious bridge unit under way

Since the dissolution of the Ministry of Supply in 1959, the Establishment has come once again under the War Office and it consists of four technical wings. They are the Bridging and P.O.L. (Petrol, Oil and Lubricants) Wing, the Structures Wing, the Mechanical Equipment Wing and the Pavement Construction Wing. Each of these demonstrated some of its work and an unfortunately limited amount of time was also made available in the Open Day programme to view the facilities of the Research Group, which supports the technical wings, and such other facilities as the Electrical and Mechanical Test House. The latter contains three engine test cells, well sound-insulated, one being used for testing water pump sets, another for generating sets and the third for engine type approval tests. Each cell has four test beds and a maximum total capacity of 350 b.h.p. ; the generating set cell also contains an automatic shut down gear designed by the Establishment and observations obtained during the cycling tests carried in it are recorded by a Solartron digital data recorder especially produced for the Establishment.

A major feature of the demonstrations, which was provided by the Structures Wing, consisted of the Gillois amphibious bridging vehicle. Five of these French-designed and German-produced vehicles have been purchased by the Army and they are now being evaluated. Each vehicle is essentially a self-propelled pontoon which can be driven on land or in water. On the road the vehicle is approximately 10ft wide, 12ft 6in high and



An amphibious unit with the deck aligned fore and aft



The high-speed road surfacing unit

40ft long and weighs about 30½ tons. Before it enters the water two full-length rubber side floats are inflated—an operation which is said to take about thirty minutes—and the vehicle width then increases to 19ft. In water the four wheels of the vehicle are retracted and propulsion is by means of a single screw. Each vehicle carries a section of 13ft wide bridge decking or a power-operated ramp, which is mounted on a turntable, swung into position across the vehicle and joined to other sections to form a complete bridge or raft unit. The end ramps of such a unit may be detached from their carrier vehicles and the 104ft long raft which was demonstrated was built up by four vehicles of which only two were left when the ramp carriers were detached. Such a raft can carry vehicles of the 40-ton class and can be used in streams whose flow is up to 8ft per second ; it can also be used in as little as 2ft of water and the end ramps can cope with banks up to 8ft above water.

In contrast to floating bridges, ferries and tank bridging, for which the Structures Wing is responsible, fixed bridging is the concern of the Bridging and P.O.L. Wing. As the designation implies, this wing is also responsible for the storage and distribution of petrol, oil and lubricants, or P.O.L., and for outboard motors, which were shown fitted to the three-man rubber reconnaissance boat and the larger, Mark IV, assault boat capable of carrying a section of infantry. Carrying one and two men respectively and fitted with several different types of motors, the two types of boats were demonstrated manoeuvring at up to 20 knots but a problem which obviously remained was that of excessive engine noise with the reconnaissance type.

P.O.L. equipment was demonstrated at the Hurn Site, located some distance away from the Establishment's facilities at Christchurch. It included a 35-ton "D" size Dracone collapsible oil barge, intended for use between tankers and beachheads and capable of being towed at up to 11 or 12 knots ; for major seaborne operation the larger 370-ton "K" size Dracone would be used. The principle which underlies much of the development of P.O.L. equipment is to carry fuel in bulk as far forward as possible and one of the features of the demonstration was the rapid laying of a flexible pipe line and the pumping of fuel from the Dracone into a collapsible 10,000 gallon pillow tank. When the pipe lines are eventually recovered, a problem is usually posed by the fuel which remains in them and to overcome this an interesting line clearing method was demonstrated employing Malony's sphere injector.

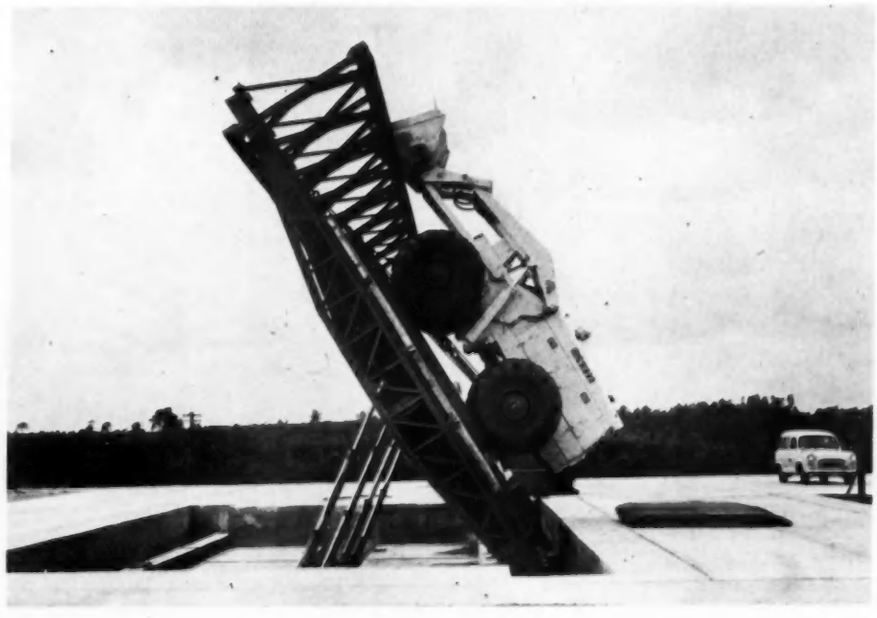
Also shown at the Hurn Site was a new high speed road surfacing unit. This is based on a Scammell "Constructor" chassis adapted to carry a 650-gallon tar tank and a hopper with 11 to 12 tons of grit, sufficient for about ½ mile of 6ft wide road surface. From the tank, which is provided with a heater, tar is pumped to a triple spray bar located behind the rear wheels, one, two or three bars being used depending on the speed of the vehicle. The tar circuit is kept hot by means of a hot oil jacket and the tar is sprayed at about 220 deg. to 240 deg. Fah, so that a more viscous type may be used. The grit is pushed out of the hopper by a tail gate operated by two hydraulic rams, one on either side of the vehicle, and its rate of delivery is controlled by a hydraulically-operated gate which is set according to the speed of the vehicle. As it issues past the control gate, the grit does not fall immediately on the road but on to a moving belt, which moves at the speed of the vehicle so that when the grit eventually drops off the belt it has no horizontal component of velocity relative to the road surface. This helps to deposit the grit more evenly and reduces any tendency for it to roll, dragging the tar to the top of the new surface ; in turn, this reduces the tendency for the grit to be picked up by other vehicles, which may be driven immediately over it after the grit has been laid, as was shown during the demonstration. The features mentioned above also make it possible to surface at a much higher speed than has been the case hitherto with other equipment, the operating speed of the new unit ranging from 3 to as much as 15 m.p.h.

The high speed surfacing unit appears most suitable for resurfacing well-maintained roads, but it has been used experimentally to lay down a road surface on virgin ground which had been only roughly graded. In the latter case several passes were, of course, necessary. The unit was developed to meet a military requirement but it has considerable commercial possibilities : one is now also being built for the U.S. Army.

Developments in the field of road and airfield surfacing are the responsibility of the Pavements Construction Wing, which is also concerned with soil stabilisation and terrain evaluation. Terrain evaluation consists largely of a broad classification of types of terrain and their general characteristics, including the underlying rock type and climatic conditions, from which some indication of, say, vehicle performance in any particular terrain may be deduced by relating it to known performance in similar terrain elsewhere.

Of more specific value is the bogging pit constructed at the Hurn Site. The pit has been developed to assess the performance of wheeled and tracked vehicles under conditions similar to those encountered on river banks or beachhead but it is, in fact, of more general value and interest. It provides a site where vehicles may be tested under very adverse ground conditions and where the ground characteristics are known and remain constant from test to test, which is not generally the case on vehicle proving grounds. The pit is about 200ft wide and 260ft long and is divided longitudinally into two halves, one filled with clay and silt and the other with peat and organic matter, the depth ranging from 1ft at the shallow end, where the vehicles enter the pit, to 4½ft at the other end ; the bottom of the pit consists of a 6in layer of stabilised soil. The pit is normally kept flooded to a depth of 3in to 4in and the water is only drained off to uncover the surface of the bog prior to a test.

Other facilities at the Hurn Site include a



The tilting platform at M.E.X.E.

rocking platform for the determination of the centre of gravity and a tilting platform for the determination of the lateral stability of construction plant equipment, which is the responsibility of the Mechanical Equipment Wing. Both platforms have a capacity of 40 tons and the tilting platform can be tilted at up to 60 deg. to the horizontal. Also shown was a dynamometer vehicle for testing the drawbar pull of tracked tractors. It consisted of a modified "Churchill" tank which had been fitted with a control cab in place of its turret, a six-cylinder Leyland diesel instead of its original twelve-cylinder Bedford engine, and two 70 h.p. hydraulic pumps which are driven off the transmission and provide the necessary drag when the vehicle is being towed and the engine drive is disconnected. The vehicle weighs about 40 tons and has a pull capacity of 80,000 lb.

Tower Cranes

There was recently demonstrated at the works of George Cohen, Sons and Co., Ltd., an improved design of the "Pingnon" tower crane which is made in seven capacities. These cranes are adaptable for use as static or travelling machines or for "climbing" duties as erection of a building proceeds.

A NUMBER of improvements to speed erection and increase the range of application have been introduced in seven new models of the French-built "Pingnon" tower cranes which are distributed in this country by George Cohen, Sons and Co., Ltd., Wood Lane, London, W.12. The smallest of these new cranes has a maximum lifting capacity of 2 tons or 16 cwt at its maximum radius of 65ft 7in, whilst the largest model of 3 tons capacity lifts 24 cwt at the maximum radius of 98ft 5in. All of the cranes are designed for static, free travelling or climbing applications. The smallest capacity machine has a maximum height of 263ft in static and 106ft in its travelling applications, and the largest capacity machine a height of 272ft in static or 135ft in its travelling arrangements. A 5-ton crane, with a capacity of 2 tons at 120ft radius, will also be available shortly.

The new cranes are of horizontal or saddle jib design with the jib and counter-jib assembly carried on a slewing head mounted on an "inner mast" riding within the upper section of the main mast and capable of being "climbed" to allow for the insertion of additional mast sections. The motors and mechanism for slewing and trolleying are carried on the inner mast and jib assembly, while the main hoist motor is located at the base of the main mast. Each section of the mast is composed of two facing panels together with the bracings which form the remaining two sides.

The feature of the improved design, which is the basis of the new, fast erection technique and of the climbing system, consists of an erection "screw" mounted vertically on the outside of the inner mast. This screw carries a supporting beam which can be traversed the full length of the inner mast when the screw is rotated. The screw is mounted in a bearing block at the lower end, and it is rotated by the slewing motor, which has double windings. One winding is used during normal high-speed operation when slewing; the other, heavy duty, winding is used for the screw drive. A switch for selecting the required motor power is mounted in the contactor panel and is operated by a key as a safety precaution. Drive to the screw is provided through the slewing gearbox, which is equipped with a lever to lock the jib in position for the climbing operation.

The screw is used for three distinct duties: the erection of the inner mast; the raising of the inner mast within the main mast; and the climbing of the crane when provided as a climber within a building. We are informed that initial trials indicated that the use of the screw system could be expected to cut erection times by about 50 per cent.

The base and inner mast assembly shown in one of our illustrations are delivered to the site as one integral unit. The inner mast is carried in a trunnion mounting within the base mast section and set in a horizontal position for transport. In this condition, all motors, enclosed gearboxes and winches of the crane are in position, together with the contactor panel, controls and wiring. On site it is only necessary to fit the axles and bogies in the case of the standard rail-mounted machine, and to set the complete unit on the prepared track. The erection of the inner mast can be carried out immediately the power supply has been connected, the screw drive selected in the slewing gearbox and the slewing motor switched in for heavy duty. The counter jib is laid out and connected to the slewing head and, by operating the slewing control, the screw and beam then raise the inner mast to the vertical. The

Tower crane with the inner mast, jib and counter-jib assembly telescoped through the first outer mast section and ready for the fitting of a further section

Crane assembly showing counter-jib ties being bolted together with the inner mast at an angle of approximately 45 deg. to the ground

main mast bracings are then fitted together with the base ballast, and the main hoist winch is used to raise the ballast to the counter jib.

Raising of the jib, complete with trolley and trolley rope, is also carried out by the main hoist winch, and the hoist rope is reeved through the trolley and return block ready for normal operation. At no further stage is the hoist rope required to be re-reeved. The remaining work of erection consists of the insertion of further main mast sections to bring the crane up to the required operating height. In this sequence one set of side bracings is first bolted to the corresponding mast panel. This panel is then raised by the crane on a cantilever lifting bar and trolleyed in until it can be fitted round the inner mast and bolted in position. The second panel, fitted with side bracings, is then raised and bolted round the other two sides.

Before the next section can be inserted, it is necessary for the inner mast to be raised and to do this the supporting beam on the screw is brought down until it bears on the top of the main mast. As the screw continues to turn, the complete inner mast and jib assembly is raised within the main mast. When sufficient clearance for the next section has been achieved, lock brackets are inserted in the main mast and the inner mast lowered a few inches on to them. With the brackets bearing the weight of the assembly, the beam is then reversed up to the top of the screw and the new mast section inserted as before. This process is repeated until the mast has reached operating height.

The erection of the crane on a static base follows the procedure for erecting the machine as a rail-mounted crane, excepting only that the mast base section and inner mast assembly are first lowered on to the previously prepared base instead of on to a rail track.

When a crane is to be used for climbing the inner mast and base assembly are delivered to site, complete with motors, wiring and controls. In this case, however, further main mast sections are replaced by an additional inner mast section. No special climbing frame is required, nor is any additional climbing winch called for.

To enable the crane, carried within the lift shaft of the building, to climb one floor at a time, a special adjustable strut is fitted to the beam of the screw mechanism. The lower end of the strut bears on channel beams across the lift shaft opening, and operation of the screw causes the beam to drive down the screw and, by so doing, to raise the crane through a complete floor in one continuous operation.

The cranes are fitted with audible and visual overload alarm systems and in the event of overloading—signalled by a red light and a klaxon—outward movement of the trolley and the hoist motion only are cut out. The driver is then free to lower and/or trolley-in his load without any delay for contactors to be reset. Control of all motions is available from the cab mounted within the inner mast, and also from a remote control panel, enabling the driver to operate from the most advantageous position at any given time.

Research in Civil Engineering

At the annual dinner of the Institution of Civil Engineers on Thursday of last week Lord Hailsham proposed the toast of the Institution. He revealed an enthusiastic appreciation of the work that engineers do and pleaded in a stirring speech for more energy and drive and courageous iconoclasm in the doing of it. We print substantial extracts below.

THERE are two closely related but highly significant facts that have impressed themselves upon me during the time—the last four years—in which I have been responsible for civil science : the key importance of engineering in the economic future of this country, and the insufficient weight at present being attached to it in our economic and intellectual life. In civil engineering, this is borne out by the Report of the Advisory Council on Scientific Policy. This is what they say : "There are considerable sectors (of applied science) where the entire research and development effort is much too small. In civil engineering, for example, we were advised that there is a serious deficiency over the whole field. . . . The difficulty experienced in finding suitably qualified men for research is particularly evident in branches of engineering where the tradition of research in our Universities has been weak, and we believe that this weakness is the kernel of the problem."

When I spoke recently to the Association of Consulting Engineers, I referred to Britain as an "underdeveloped country." Is this too much of a paradox ? I am not at all sure that it is. Obsolete development is in a sense more insidious than lack of development. Consider the facts. Our railway tracks and their principal stations were largely engineered before 1855. How much research and development is being done on locomotives and rolling stock, either by public or private enterprise ? Surely our civil engineers cannot remain indifferent to the engineering problems of a modern transport system. What are the dates of our principal docks and port facilities ? What are the methods used in them for handling goods ? Our roads, we know, were in some cases engineered by Roman civil engineers —especially at road intersections at the centre of towns. How many of our bridges, road or rail, are more than 100 years old ? How many buildings and large structures of all kinds would have been pulled down in the 1920s had they been sited on the other side of the Atlantic ? Then look overseas : the scope for good civil engineering is infinite. Of what use is the claim for equality in underdeveloped countries if it is not accompanied by plans for roads, railways, port facilities, airports, dams, irrigation schemes, power stations—in short, for engineering structures of all kinds ? And can we hope to survive as an exporting nation without civil engineers capable of competing with the world ?

Engineering as an Artistic Science

Engineering is by far the most artistic of the sciences. It is not simply that the really classic designs of the past—Brunel's bridges and railways for instance—are essentially beautiful. It is that all engineering design is, in its inmost being, creative. Incidentally, I am not at all sure that it is not a failure to recognise this fact which makes some engineering teaching a little uninspired. It is not for me to dictate the content of curricula. But could not the teaching institutions here do a little more about teaching engineering design ? And could not more undergraduate courses include at least one project ?

Soviet Science

We hear a great deal nowadays about the successes of Soviet science. These successes are not the result of magic, or the result of any inherent advantages of the Soviet system. Indeed, the latter has so many built-in disadvantages as to make their technological achievements even more remarkable. All dictatorships start with one built-in advantage which we cannot fully imitate in time of peace—the concentration of effort. But the underlying achievement of Soviet technology has been due to two factors both of which we could reproduce here if we had half a mind to it. One is that the thinking inside the system is firmly hitched to science and technology, and in particular to a powerful scheme of scientific education. The other is that they have achieved an extremely successful marriage between science on the one hand and engineering and technology on the other. Any society which pursues these principles to their logical extent, whether it is a Socialist or a private enterprise society, can achieve comparable results. But no society can do so unless it really is prepared to bestir itself in pursuit of these objectives. In the war of ideas, science and technology are benevolent neutrals, willing to ally themselves with either side which seeks their aid. Have we in our society sought their aid enough ? Despite Biblical injunctions to the contrary, we must put new wine into our old bottle, or bust. And it is precisely this enthusiasm and virility that most needs showing at the present time. Some five years spent in Government circles has persuaded me that there is far too much intellectual pauperisation in the general mental climate of this country. When things go wrong we tend to blame the Government, or, if we are in the Government, our colleagues, and to think that things can only be put right in this or that Department, or this or that industry, if we go whimpering round to the Treasury for more money or discriminatory tax relief. According to my own philosophy the only criticism which is any good to anybody is self-criticism, and the most constructive suggestions one can offer are the ones that one can offer to carry out oneself.

Objectives for the Future

However, I suggest that here is a series of objectives we can all set ourselves for the immediate future. Let us bring about a situation when engineering will be recognised in this country—and particularly in the Universities and in industry—for what it is : one of the most worthwhile and constructive occupations that a man, or a woman for that matter, can follow. Let us see to it that the content of our engineering courses is fitted for the requirement of the life that their graduates will have to lead, combining wherever this is necessary a proper grounding in management studies as well as a technical training in engineering. Let us see to it that our school courses at least contain enough mathematical and scientific teaching to make possible at all levels an adequate supply of technologists, technicians and craftsmen. Let us aim at the continuation and expansion of civil engineering research in every field for which we are responsible : the contractors in theirs, the D.S.I.R. stations in theirs, the Universities and Colleges of Advanced Technology, and, not least, the industrial research associations and industrial firms in theirs. But, above all, this Institution has itself a responsibility and a role in this field. No profession nowadays can ignore research or afford to leave education solely to the Government or to the educationists. Moreover, let us try to see to it that the results of research shall be published, and shall be applied in practice as quickly as possible. In carrying this out I would think that your Institution and its expert committees have an indispensable part to play.

Self-Reliant Iconoclasm

And let us spread abroad a sort of self-reliant iconoclasm, a spirit which is more concerned with efficiency and thoroughness than with keeping up appearances or mere respect for tradition. It seems to me that at the present time this country is far too preoccupied with pay, prospects and status, far too conscious of tradition and rights, far too afraid of change, far too squeamish about offending prejudices and treading on corns to succeed. We must look at the achievements of our ancestors as incentives to future effort and patterns for emulation, not as ancient monument, or immutable law and custom ; otherwise we shall not maintain our heritage in a world that has changed from the one that our ancestors knew.

SHORTER REPORTS

Testing Boiler Flue Gases for Corrosive and Fouling Tendencies

THE problems of external fouling and corrosion resulting from certain active gaseous and particulate constituents of boiler flue gases have closely concerned the Boiler Availability Committee, 8, Waterloo Place, London, S.W.1. Since its inception this committee has realised the need for establishing suitable methods for the rapid assessment of potential trouble from these causes with a given boiler, fuel or method of operation.

Although specific techniques have been described, in papers and in the technical press, it is believed that the relative effectiveness and limitations of these methods are not widely known. Accordingly, the Boiler Availability Committee has now published a 68-page bulletin (No. 11) entitled "Testing Techniques for Determining the Corrosive and Fouling Tendencies of Boiler Flue Gases" which gives concise details of suitable test methods. To ensure that results are comparable, sufficient details are given to enable recommended techniques—some of which were originally developed by the committee—to be applied successfully without reference to other sources.

Testing methods are divided into two main groups. First, there are techniques for investigating low-temperature corrosion and its causes; meters for measuring "acid dewpoint" temperature, corrosion probes, instruments for determining sulphur dioxide and sulphur trioxide, also "acid-deposition" probes are described. The second group comprises techniques designed for the determination of the nature and extent of high-temperature fouling and includes probes for measuring the rates of deposition of various constituents of fuel ash. All methods are necessarily based on the insertion of one probe, or a number of probes, into the gas stream and inherit the limitations inherent in this technique. The bulletin does, however, contain many useful hints on correct sampling techniques to achieve the maximum degree of accuracy at reasonable cost in time and equipment.

Most of the procedures described are intended for tests of short duration, being designed to yield results within the hour. Such tests are ideal for the detailed investigation of rapid changes in boiler conditions. They are thus better suited for the comparison of different methods of boiler operation, or of variations in fuel characteristics, than the precise prediction of the period of trouble-free service likely to be obtained from a given component.

Some of the tests listed are suitable for use over longer periods. For example, a liquid-cooled corrosion probe is described which can operate without attention for a period of 100 hours or more. During such prolonged tests the parameters under investigation inevitably change. Long-term tests are thus not suited for the precise determination of optimum operating conditions for boilers and are in fact complementary to short-term tests. The latter are best employed initially to compare the potential effects of different operational variables on corrosion. Once optimum conditions have been established, long-term testing offers a means of determining the average corrosion to be expected under these conditions, and provides an indication of the likely frequency of boiler outage for cleaning. Also, the results may reasonably be extrapolated to give some idea of the likely life of items of boiler equipment subjected to such conditions.

Careful attention is paid throughout the bulletin to the safeguards essential to ensure the correct operation of instrumentation in a boiler room. Details are also given of methods for obtaining the maximum accuracy in each test, even under adverse conditions. Assessment of test results is facilitated by an indication, wherever practicable, of the errors inherent in the methods described.

An important consideration has been that the testing techniques discussed should not involve an excessive demand for highly trained technical staff. It is of course necessary for an experienced technologist to be in charge of a test programme but, given adequate supervision, non-technical personnel, after a brief period of instruction, can make up the investigation team.

It is recognised by the Committee that the methods laid down will be subject to continual development and that current research is likely to lead to new and improved techniques. In particular, considerable effort is now being expended to substitute automatic recording instruments for hand-operated apparatus. It is therefore intended that the present work should be kept up to date by the periodic issue of revised and supplementary bulletins.

Industrial organisations are advised that copies of the bulletin may be obtained only from British manufacturers of watertube boilers, by application to the nearest representative or agent, at home or overseas.

[Reply Card No. E8701]

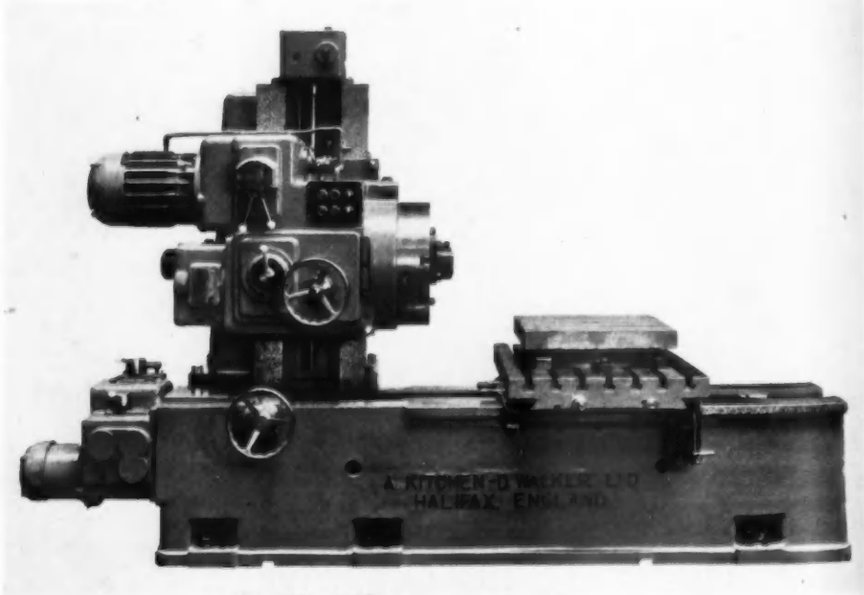
Horizontal Facing Machine

A HORIZONTAL facing, boring and turning machine has been introduced by A. Kitchen-D. Walker, Ltd., Hexagon Works, Pellon Lane, Halifax, Yorks, for operations on pipe flanges, valve bodies and similar components.

The machine, illustrated below, is driven by a 7½ h.p. constant speed motor through a gearbox giving nine faceplate speeds 216 to 17 r.p.m., the final drive being by helical gears. The facing head is mounted on pre-loaded taper roller bearings and carries the facing slide which has two rates of automatic feed; $^{1}/_{16}$in and $^{1}/_{32}$in per revolution, forward and reverse by scroll feed. In addition to the power feeds the facing slide can be adjusted by handwheel whether rotating or stationary, through a differential gear assembly, a micrometer dial being provided for precise adjustments. The head has 18in of vertical adjustment.

The 3ft 6in by 2ft 6in main table has 3ft of traverse forward and reverse along the main bed by power, there being three rates of power feed, ¼in, 1in and 1½in per minute, and three rates of rapid traverse, 24in, 48in and 72in per minute. A handwheel is provided for fine table settings and 30in of cross adjustment by hand is provided.

Squaring tables which are available can be either 24in or 30in square or circular. These tables have four definite 90 deg. setting positions and a lift motion incorporated breaks the joint faces to allow easy rotation on ball bearings. Double locks fitted to the tables and head ensure the rigidity of the machine under heavy duty working conditions.



Horizontal facing, boring and turning machine

Industrial Health Clinic for Small Firms

THE first clinic of the Slough Industrial Health Service to be established outside Slough Trading Estate was opened at Colnbrook, Bucks, recently, by the Minister of Labour, Mr. John Hare. It will serve the sixty firms on the Poyle Industrial Estate, Colnbrook. Some of the firms on the estate employ less than twenty-five workers each, and it is for these smaller concerns in particular that the scheme has been brought into operation. It is not, however, confined to smaller businesses. On the contrary, any firm on the site is eligible for membership and nearly half the companies there have already joined, bringing some 1500 employees into the scheme.

By co-operative effort the member firms are able to provide a comprehensive health service for their employees which would be out of reach of all but the biggest undertakings. It is all the more important that such a service should be available as the National Health Service makes no provision for health care at places of employment. Member firms pay 10d. per week for each employee, and this gives them the right to use all the facilities of the Slough Industrial Health Service. These are:

(1) Assisting in the provision of safe and healthy working conditions by scientific investigation and control of industrial hazards.

(2) Provision of emergency treatment for sick and injured employees while at work.

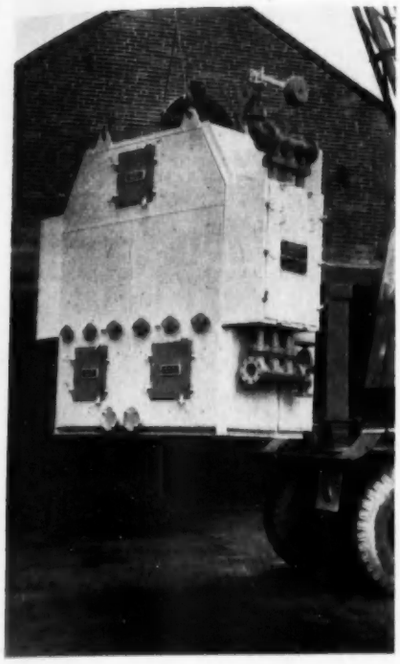
(3) Provision of rehabilitation facilities for workers incapacitated by injury or illness.

(4) Giving of advice and practical help in the social and domestic problems of workers.

The new clinic at Poyle, which has been built and equipped by means of a grant from the Nuffield Provincial Hospitals Trust, consists of a waiting room, consulting room and treatment room. It is open daily from 8.30 a.m. to 5.50 p.m., and is equipped to deal, in the first instance, with all cases of injury or illness occurring at work. A doctor is in charge, and there is a full-time industrial nurse.

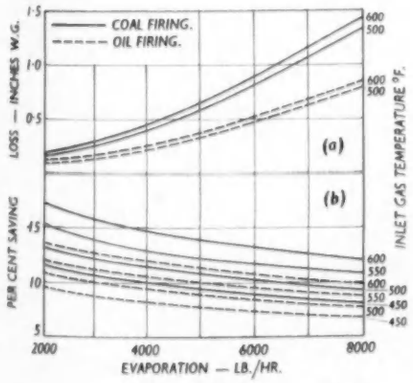
Economiser for Small Boilers

To enable small boiler plants, having an evaporative capacity ranging from 2000 lb to 12,000 lb per hour, to achieve the best possible fuel economy or steaming capacity, E. Green and Son, Ltd., has introduced a compact economiser unit. This is known as the "Unicon" and, as seen in our illustration, it is in the form of a self-contained shop-assembled unit



A "Unicon" economiser for small boilers

competely cased and insulated, with dampers and duct connections and placed between the boiler and induced fan to provide maximum performance using the minimum of space. The design is based on the company's Premier Diamond Type 25, but is in no sense a scaled-down version of this unit. It is a full-size economiser employing standard cast-iron gilled tubes and connecting bends and the diamond-shaped



	Coal		Oil
Gases per 1 lb water	2·5 lb	...	1·8 lb
Boiler pressure (no superheat)	120 lb per square inch	...	120 lb per square inch
Feedwater temperature	120 deg. Fah.	...	140 deg. Fah.

Performance curves (*a*) economiser frictional draught loss and (*b*) fuel saving due to economiser

tube body and rectangular fins give high rates of heat transfer with low draught loss.

Four sizes of the "Unicon" are available, with twelve, sixteen, eighteen and twenty-four tubes, the respective heating surfaces being 504, 739, 832 and 1109 square feet, and are designed to operate with boilers having pressures up to 650 lb per square inch and evaporative ratings up to 10,000 lb per hour. The self-contained design of the units, which are completely insulated with end casing and doors to enclose the circulating bends, makes them suitable for installation either indoors or out of doors and the gas flow can be either upward or downward without the need of modification. Here we append a graphical record of performance data for a "Unicon" economiser of eighteen tubes 8ft long (three tubes wide, six tubes high) and two passes of gas, for both coal or oil firing and covering evaporation rates ranging from 2000 lb to 8000 lb per hour, and based on a boiler pressure of 120 lb per square inch with no superheat. For coal firing the gases per pound of water are assumed at 2·5 lb, the corresponding figure for oil firing being 1·8 lb, while the respective feed water temperatures are 120 deg. and 140 deg. Fah. From the specimen curves it can be seen that with coal firing the saving of fuel at an evaporation rate of 2000 lb per hour is 17 per cent with an inlet gas temperature of 600 deg. Fah. and 14 per cent with an inlet gas temperature of 450 deg. Fah. At an evaporation rate of 8000 lb per hour the corresponding fuel savings are 12½ and 8 per cent respectively.

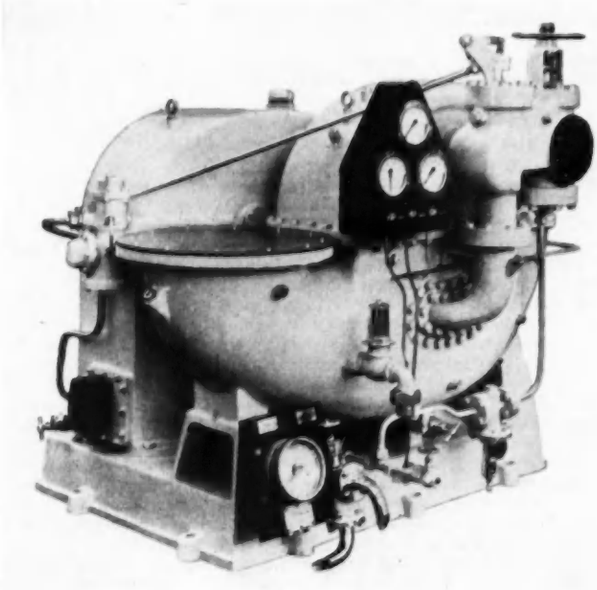
[Reply Card No. E8711]

High Vacuum Exhaust Steam Turbine

Recently added to the range of auxiliary turbines manufactured by G. and J. Weir, Ltd., is the "LPI" which we illustrate and which is of horizontal geared pattern intended for service in motorships where high-pressure steam is not available. Of simple impulse design the turbine has one pressure and two velocity stages and is designed for steam conditions of 250 lb per square inch gauge at 750 deg. Fah. and developing a maximum of 850 b.h.p. A speed range down to 30 per cent of full load speed can be obtained so the unit is suitable for driving cargo oil pumps. Running speed is attained in four to five seconds and starting torque is about twice full load torque, while driving torque is constant throughout each revolution of the rotor ensuring a vibration-free drive.

The turbine casing is split along the axis of shaft to give access to the overhang wheel, which is supported at each end of the gearbox in sleeve journal bearings. Hard carbon fitted glands, to which a sealing steam supply is led, seal the shaft at the gearbox side. All steam joints are made on bottom half casing so that none are broken when the top half casing is removed. The gearbox, of conventional design consists of single helical reduction gears and the forced lubrication system is supplied by a pump, mounted in a separate housing bolted to the gearbox, driven through worm gears from the main turbine shaft. Michell thrust bearings in the gearbox take the turbine thrust. Two safety trips of eccentric ring pattern, are fitted to the turbine, one operating at 7½ per cent and the other at 15 per cent above normal running speed and are accommodated in the output end of the turbine shaft in the oil pump housing. The accuracy of speed control required determines the design of governor fitted and there are available a fine control valve, which provides for the steam supply to be adjusted to a fine degree, and an hydraulic governor. This gives accurate control to within ±2½ per cent down to 30 per cent of running speed. Other main particulars of the unit are: maximum rotor speed, 8500 r.p.m.; output shaft speed, 1200 to 1800 r.p.m.; exhaust vacuum up to 28in Hg.; steam inlet diameter 4in; steam exhaust diameter 18in.

[Reply Card No. E8712]



850 b.h.p., high vacuum, exhaust steam geared turbine for steam conditions of 250 lb per square inch gauge and 750 deg. Fah.

Economiser Studies

In the "split economiser" or "series feed system," the feed-water passes direct from the deaerator into the boiler's low-temperature economiser, out again through a h.p. bleed steam preheater and thence back and into the boiler's high-temperature economiser. For this system it is claimed that it gives an improved economy which will repay the additional capital cost within a short period. The De Laval Ljungstrom Turbine Company states that it has recently investigated the best use of the split economiser to establish its optimum operating characteristics with respect to both economic and technical considerations. The machinery investigated consisted of main turbines developing 20,000 s.h.p. with a condensing turbo-generator system and with the following steam data: pressure at superheater outlet 600 lb per square inch gauge; temperature at superheater 900 deg. Fah.; and condenser pressure 28·5in Hg. A number of heat cycles were calculated, with the assistance of manufacturers who provided costs and technical data, and comparative costs, capital investment and optimum boiler conditions from both technical and practical considerations were taken into account. Economic tables and graphs were prepared relating to investment and oil costs for a given amortisation period. The results of the investigation, the company states, indicated that the low-temperature part in an economiser was redundant, while the best system was found to be that employing only a high-temperature economiser and a h.p. bleed steam preheater.

SHORTER REPORTS *(continued)*

Transmitters for B.B.C. External Services

Two new 100kW short-wave transmitters have been installed at the External Services transmitting station of the British Broadcasting Corporation at Rampisham, Dorset, as part of a long-term plan for modernisation and re-equipment of the Corporation's short-wave services. The design of the new transmitters, which were built to B.B.C. specification by Marconi's Wireless Telegraph Company, Ltd., departs from earlier practice in that vapour cooling is used for the valves in the final radio-frequency amplifier and modulator stages. In this system the heat from the valves is tranferred to water jackets surrounding them, where it produces steam ; this is carried by convection to an air-cooled condenser which re-converts it to water for return by gravity feed to the water jackets.

Below we show a Rampisham transmitter in

Transmitter in course of erection, showing water jacket of vapour-cooled valve in foreground

course of construction, the mounting jacket for one of the valves is seen in the foreground. The vapour-cooled valves have been made by the English Electric Valve Company, Ltd.

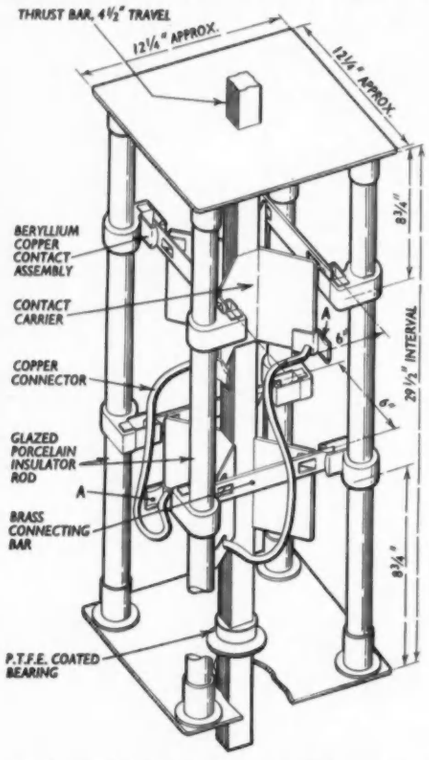
Special attention has been given to providing means for rapid change of operating frequency, in order to maintain adequate service under constantly varying propagation conditions. With the new equipment a frequency change can be carried out in a few seconds by a simple switching operation which has been made possible by the provision of two radio-frequency amplifiers for each transmitter. These amplifiers, contained in separate cabinets, are located on each side of a common modulator which can be switched to either. Thus, while one radio-frequency amplifier is in use the second can be set up on another frequency and the scheduled frequency change made almost instantaneously.

In addition to changing the transmitter frequencies at scheduled intervals, it is necessary to switch a transmitter to different aerial arrays designed to radiate in a particular waveband and on a certain bearing, thus ensuring a maximum signal in the target area. For this purpose B.B.C. engineers have developed a new form of electro-pneumatic switch which is remotely controlled from inside the station and enables the output of a transmitter to be connected to a selected aerial feeder. The system installed at Rampisham has already been tested under operational conditions at the B.B.C. External Services transmitting station at Skelton, Cumberland. It enables either transmitter to be switched to any of eight directional aerial arrays with an actual switching time of less than five seconds. Provision has been made in the design for extending the system to six transmitters and fifty arrays when required. Since the system is experimental, and has been made to fit in with the original layout of array feeders, some departures from the optimum arrangement have been necessary.

In the radio-frequency feeder layout adopted, the feeders from the transmitters, all at the same height of about ten feet above ground and parallel to each other, are crossed by the feeders to the aerials, all at a higher level. The remotely-controlled switches can be located where the feeders cross as required by the operational schedule. It has been convenient to run the transmitter feeders round three sides of a 120ft square, of which the aerial feeders are " radials." Each switch consists essentially of two double-pole changeover switches mechanically coupled to one another, and capable of switching over 100kW of radio-frequency power between feeders of 320 ohms characteristic impedance.

The arrangement of a switch is shown below. It has two positions :

(*a*) A lower, or disengaged, position (illustrated) in which both transmitter and array



Feeder switch in lower (" disengaged ") position

feeders are switched straight through by means of the horizontal connector bars. The electrical characteristics of the switch and its physical position in line with the feeders ensure a voltage standing-wave ratio of not worse than 1·04 in this position.

(*b*) An upper, or engaged, position in which both feeders are interrupted, and the live side of the transmitter feeder is routed to the outgoing aerial feeder by means of contacts *A*. The v.s.w.r. is not much worse than 1·1 in this position.

The form of feeder used is 6in by 2in, six-gauge, four-wire line. This is the first time the B.B.C. has made extensive use of such a line, which will, however, eventually replace all 10in by 6in six-gauge line for powers of 100kW.

The motion of the switch is provided by a compressed-air cylinder, mounted with its axis vertical directly below the switch. The linear motion of a piston in the cylinder is transferred directly to the switch. Two 50V a.c. solenoid valves control the admission of compressed air into either end of the cylinder. Operating pressure is 40 lb per square inch through a reduction valve from the main distribution pressure of 150 lb per square inch.

The operating supply (50V a.c.) for the solenoid valves is fed *via* a control cable in a concrete cable duct leading from the aerial switching bay in the main building. This duct also contains the compressed-air line. The operating voltage is itself controlled by 50V d.c. relays on the aerial switching bay. The position of the switch is indicated back to the control panel on the bay by means of limit switches which are operated by a cam at the extremities of travel of the r.f. switch, while the aerial switching bay controls are interlocked with the transmitter control circuits so that a switch cannot be operated on load. Facilities exist on each switch assembly for manual operation in the event of a failure of either the compressed air or the 50V a.c. supply.

Two more 100kW transmitters similar to those at Rampisham were ordered recently from Marconi's Wireless Telegraph Company, Ltd., for installation at Daventry. A further development at Daventry, associated with the requirement for rapid changes of frequency in short-wave broadcasting already mentioned, has been the application of a vacuum capacitor in one of the existing h.f. transmitters. The capacitor, one of the range introduced by the English Electric Valve Company, Ltd., as noted in our March 3 issue, page 348, is in the grid circuit of the penultimate r.f. stage. It has a capacitance of 5·5pF to 206pF and overall dimensions of 9·5in by 3·5in, and replaces a conventional 5pF to 37·5pF air dielectric capacitor which was 12in long by 4in square. With the extra available capacitance, only one coil change is required to tune the transmitter from 21 Mc/s to 6 Mc/s. The sealing of the vacuum capacitor also gives protection from internal flashover caused by accumulation of dust. The capacitor plates are in the form of two sets of concentric cylinders, their relative axial positions being controlled by rotation of a shaft at one end of the capacitor. Screw threads are employed to obtain an axial movement for expanding or contracting metal bellows which transmit the motion directly to one set of cylinders. The inner surface of the bellows is at atmospheric pressure and the outer surface at a very high vacuum. The compactness permitted by using a vacuum dielectric keeps fringe effects and self-inductance to a lower level than could be obtained with an air dielectric unit of comparable capacitance.

[Reply Card No. E8721]

Plastics Hose

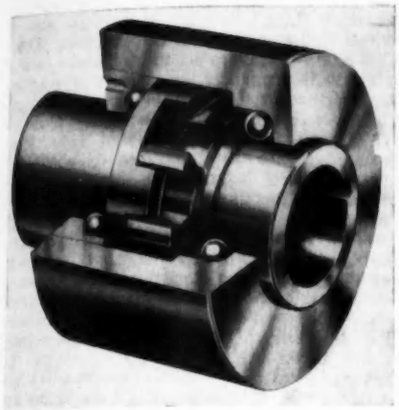
PLASTICS hose is now available from Recon (Pipelines) Ltd., Sheerwater, Woking, in sizes between 4in and 12in and in lengths up to 15ft. This " Vacuflex " reinforced thermoplastic hose is made of abrasion-resistant p.v.c. strengthened by high-tensile steel wire, a combination which gives resistance to wear and crushing.

The hose is so flexible that it can be easily bent around a radius equal to its core diameter. It is lighter than metallic ducting and is claimed to be easier to instal and it requires fewer and cheaper fittings as it can be bent round obstacles in any plane without the need for elbows and bends.

[Reply Card No. E8722]

Reversible Locking Clutches

An interesting development of the sprag clutches introduced by Renold Chains, Ltd., Wythenshaw, Manchester, some three years ago is a reversible locking clutch which can be applied for position control purposes, torque feed-back elimination, reversible backstopping and single revolution control. The construction of this clutch, which is designed for mounting in an enclosed housing, can be seen in the cut-away photograph we reproduce.



Construction of reversible locking clutch

The clutch has an outer race containing two co-axial inner races which are keyed to shafts and act as a "controller" and a "follower" respectively. Two sets of special locking elements are mounted between the follower and the outer race, one set of elements being arranged for driving in the clockwise direction and the other in the anti-clockwise direction. A slight turning movement of the controller shaft in one direction or the other actuates a set of shoes which unlock one or other set of elements to give a reversible drive.

In applications where the clutch is used for position control or anti-feedback the outer race is fixed and the controller can drive the follower in either direction. When the controller is stationary in this case the follower is locked against turning in both directions. When the clutch is used as a reversible backstop the follower is fixed and the outer race, which is driven, will lock or over-run the follower in either direction. In this case a slight turning movement of the controller will reverse the direction in which the outer race can freewheel.

To use the clutch in a single revolution control application, the outer race is driven continuously, driving the controller and follower through the locking elements. A trip device is fitted on the controller and is brought into effect to make the follower drive or stop as required without interrupting rotation of the outer race.

The clutch is available in six standard sizes with torque capacities from 6 lb feet to 2500 lb feet and having outsize diameters from just under 1¼in to 6¼in, and they are made with either ball or sleeve bearings.

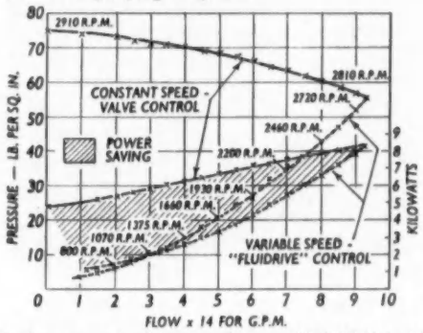
[Reply Card No. E8731]

Fluid Couplings for Control of Centrifugal Pumps

The advantages of using a scoop-control fluid coupling to adjust the speed and output of a centrifugal pump, instead of running the pump at a constant speed and throttling the discharge, were strikingly demonstrated by Fluidrive Engineering Company, Ltd., Worton Road, Isleworth, Middlesex, at the recent Engineering and Marine Exhibition held at Olympia. The practice of regulating the flow by a throttle wastes power and, indeed, at low outputs the pressure drop across the valve may considerably exceed the total demand of the rest of the system. A much more efficient method of control is to run the pump at whatever speed is required to develop just enough head to overcome the system resistance for particular flow conditions. The required characteristics are inherent in a drive system consisting of a Vulcan-Sinclair scoop-control fluid coupling fitted between a squirrel-cage motor and a centrifugal pump. This coupling gives variable speed at the pump while retaining the simplicity, reliability and economy of the constant-speed squirrel-cage motor.

To demonstrate the advantages of the system a special rig was designed and assembled. It consists of a 10 h.p., 2910 r.p.m. squirrel-cage motor (with direct-on-line starting) driving through a size-8, "SCR6" fluid coupling to control a Hayward Tyler–Byron Jackson 2×3×8 H.S.M. process pump designed to discharge about 140 gallons per minute against a head of 145ft. Manual control is provided for the fluid coupling and the pump speed is measured by a tachometer. A wattmeter indicates the power consumption of the motor. Water is discharged from the pump, through a 3in pipe fitted with a Foxboro indicating flowmeter and a pressure gauge, to a 1½in pipe containing a throttling valve. The output side of the valve is connected to a length of p.v.c. pipe which simulates a system having some frictional resistance and discharges into a tank which is connected by a pipe to the suction side of the pump. The following two methods of control can be fully demonstrated with this arrangement of plant.

1. *Constant-Speed Pump with Throttle Control.*—The pump is run at constant speed with the fluid coupling fully engaged, the flow being controlled as required by valve throttling. Values of hydraulic pressure and input power to the motor are observed over a wide range of flow conditions. Typical results are plotted in the accompanying diagram.



Performance of variable-speed pump with "Fluidrive" coupling, compared with that of constant-speed pump with throttle control

2. *Variable-Speed Pump with Scoop-Controlled Fluid Coupling.*—With the throttle valve fully open the pump speed is varied by adjustment of the control lever of the fluid coupling. For the same range of flow conditions as in Method 1 above, the pressures and motor inputs are observed and the results are plotted on the same diagram.

London Traffic Survey

Speaking at the London County Council meeting on Tuesday, May 16, on the capital estimates for road improvements in London this year, Mr. Richard Edmonds, the chairman of the L.C.C. Roads Committee, said with regard to the projected London Traffic Survey :

"The arrangements that have now been agreed between the Council and the Ministry of Transport are as follows :

"(*a*) The area to be surveyed should be broadly the greater London area.

"(*b*) Information relating to private cars to be obtained chiefly by home interviews, supplemented by traffic counts, &c.

"(*c*) Some information required for a projection of the result to 1970 and beyond will be obtained, but the best method of making the projection is still being discussed. The projection, when made, will be a separate matter.

"(*d*) The cost of the survey on this basis, and excluding the projection, will be about £425,000 ; of which about £125,000 is attributable to the costs outside the County of London.

"Provided arrangements are satisfactorily concluded, it should be possible to start on the survey almost immediately ; and the final results will be available early in 1963."

British Investment Casters' Technical Association

The third annual conference of the British Investment Casters' Technical Association held in London last week was well attended and eight papers were presented for discussion at the technical sessions.

In his paper on "Recent Developments in Alloys for Aircraft Gas Turbine Rotor Blading," Mr. E. Glenny said that during the past fifteen years the development of aircraft gas turbines with greater thrust and higher power output had resulted in the use of higher gas temperatures. For the rotor blading it had been realised that there was a temperature limit beyond which conventional alloys based upon nickel or cobalt would be inapplicable. There was little doubt that conventional alloys were closely approaching the limit of increase in temperature for present levels of load-carrying ability. Service temperatures were approximately 80 per cent of the melting point of currently used alloys. Nevertheless, metallurgists in the high-temperature alloy field had continued to confound the prophecies that nickel base compositions in particular had reached the end of the line. In his paper Mr. Glenny reviewed the properties and characteristics of alloys that have been developed for aircraft gas-turbine rotor blading during the past three to four years.

Points of particular interest in their paper "Tensile and Stress-Rupture of Nimocast 90 : Effects of Variation in Composition, Deoxidation Procedure and Grain Size" were given in a synopsis by Messrs. R. M. Cook and P. J. Penrice. It stated briefly that control of carbon content and satisfactory deoxidation technique were of primary importance in securing adequate tensile ductility in Nimocast 90 test bars. At relatively high levels of carbon, magnesium was a more effective deoxidant than calcium. Poor ductility was attributed mainly to grain-boundary segregation of titanium carbide, which was more continuous when the residual contents of deoxidant were low ; in such conditions formation of titanium sulphide inclusions might also be a contributory factor. Variations in heat-treatment, grain size and specimen size, they said, had little effect on tensile properties within the ranges studied. Reduction in titanium and aluminium contents caused a marked fall in rupture strength, with only slight increase in tensile ductility.

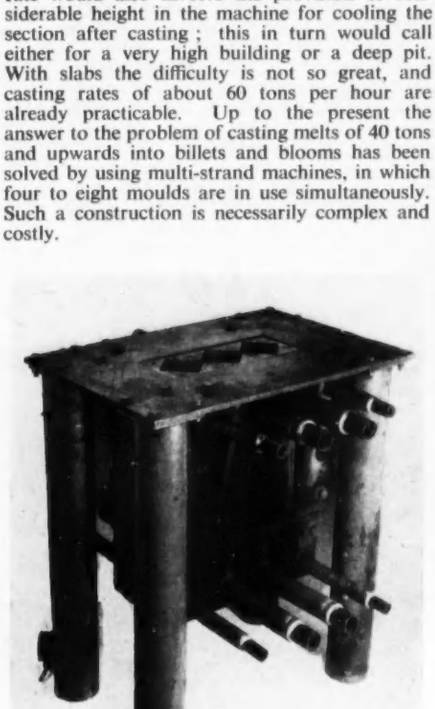
In his paper "Polystyrene : A Material for Patterns," Mr. C. H. Waxman said that polystyrene offered the investment caster some useful advantages over other pattern materials. It was tough, dimensionally stable, and had a hard surface which reproduced the tool finish extremely well. It could be produced at high rates of output, and parts made of it were easily stuck together. These advantages, together with low cost, offset the lack of recovery of the material on removal of the pattern and the higher tool cost. Mr. Waxman anticipated, therefore, that polystyrene patterns would offer economic advantages, particularly for long runs and for larger quantities off the tool. The paper surveyed the basic principles of injection moulding of polystyrene, the range of mouldings which could be obtained, and the properties of the material of particular interest to the investment caster.

More than 100 members and guests attended the annual dinner of the association, which was held at the time of the meetings. Speaking at the dinner Mr. R. W. N. Danielsen, chairman of the Association, said that at present only the fringe of all the possible markets for investment castings had been touched. In their attempts to widen the field of application for their products the members of the Association should be careful to consolidate the position of investment castings in each new user industry before extending their efforts towards others. A later speaker, Mr. F. Nixon, pointed out that a major difficulty investment casters had to overcome was a mistrust of castings in many sections of industry. There were still many who had not yet appreciated the properties attainable with investment castings, and he considered that the Association should direct greater efforts to publicising how such castings could be adopted by a wider field in industry.

SHORTER REPORTS *(continued)*

Faster Continuous Casting

ONE of the limitations of the continuous casting process hitherto has been that it has a relatively low casting rate. For sections from 2in to 10in square this rate ranges from 5 to 25 tons per hour. To increase the casting rate by speeding up the withdrawal of the billet causes deterioration in quality and introduces a risk of failure by tearing or bulging of the very weak solidified shell of the cast section. In the case of medium and large sections a faster withdrawal rate would also involve the provision of considerable height in the machine for cooling the section after casting; this in turn would call either for a very high building or a deep pit. With slabs the difficulty is not so great, and casting rates of about 60 tons per hour are already practicable. Up to the present the answer to the problem of casting melts of 40 tons and upwards into billets and blooms has been solved by using multi-strand machines, in which four to eight moulds are in use simultaneously. Such a construction is necessarily complex and costly.



Mould for simultaneous casting of three billets

A new approach to the problem has been made by the Continuous Casting Company, Ltd., Netherby, Queen's Road, Weybridge, Surrey, and the British Iron and Steel Research Association, and their jointly-developed "Weybridge" process has undergone successful trials. This process, which is based on a patented multiple mould, not only enables the casting rate to be substantially increased for any square section, but also greatly simplifies tundish and nozzle operation. The mould at present in use produces three 3in square sections, the mould cavities being arranged close together and joined, as will be seen from the accompanying illustration, by short narrow channels. Pouring is from a single tundish nozzle located over the central mould cavity. Many variations of the mould are possible; four or five cavities might be arranged in line, for example, with pouring from two tundish nozzles.

The side by side arrangement of the mould cavities lends itself to simple designs of guide and withdrawal rolls, which would be of the diabolo pattern. Similarly, there is no difficulty in designing cut-off gear and baskets for disposing of the cut pieces from the vertical to the horizontal position for further processing. Nor is there any difficulty about parting the cast section into its three square components ready for rolling. This can be done by the rolling process itself, by circular saws, or by flame cutting.

By the Weybridge process it is possible to treble the casting rate from a single strand, and so to cast 8in to 10in blooms at 50 tons to 60 tons per hour. Substantial savings in capital cost are possible, because the number of strands needed to handle the output of a given furnace in a given time is considerably reduced. Operating economies are also achieved. Although there is

Cast billets emerging from triple mould

an extra operation—parting of sections—to be considered, this is more than offset by the increased production rate which, it should be added, is accomplished without increase in casting machine labour. The number of men needed to operate a casting machine is directly related to the number of pouring, cut-off and disposal positions which have to be manned. None of these is increased by the use of the Weybridge mould. Finally, as a result of the higher pouring rates possible, reliability of operation will be increased. Many of the troubles experienced with continuous casting in the past have been due to blocking of the tundish nozzle or instability of the liquid streams. These are caused by a relatively slow casting rate, and increasing the rate will minimise failures to cast correctly.

[Reply Card No. E8741]

Type 3 Diesel-Hydraulic Locomotives

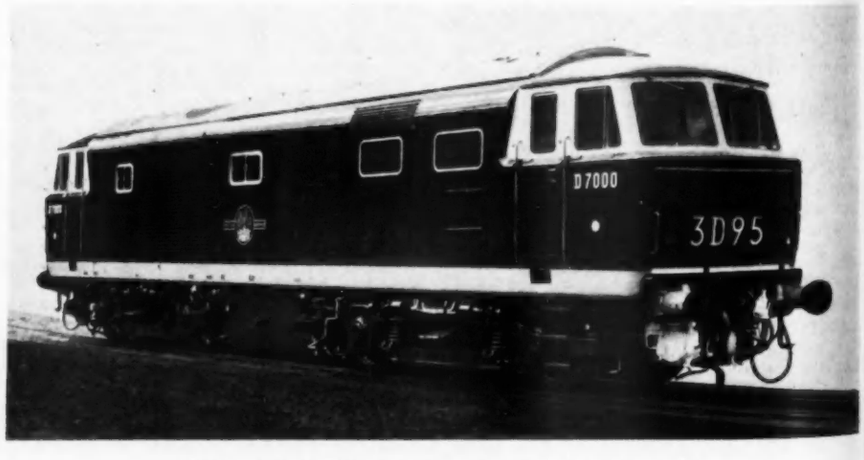
THE first of ninety-five type 3 diesel-hydraulic locomotives being built by Beyer Peacock (Hymek), Ltd., for the Western Region of British Railways was delivered last week. These 1700 h.p. locomotives are to be used for further stages in the complete replacement of steam by diesel power in the Bristol area, the West of England (west of Newton Abbot) and in South Wales. Under this plan about 1100 steam locomotives are being replaced by about 500 main line diesel locomotives.

The new locomotive D.7000, illustrated on this page, is designed for a maximum service speed of 90 m.p.h. and is intended for general purpose working. With a weight of 74 tons in working order it has a starting tractive effort of 49,700 lb (30 per cent adhesion) and a continuous tractive effort of 33,950 lb. It is powered by a Bristol-Siddeley Maybach sixteen-cylinder, four-stroke, diesel engine with turbo-charging and charge cooling. This engine is rated at 1700 b.h.p. at 1500 r.p.m., its N.T.P. rating being 1920 b.h.p. at 1500 r.p.m. Power is transmitted by a Stone-Maybach "Mekydro" hydraulic transmission and through cardan shafts to Stone Maybach final drive gearboxes on the inner and outer axles.

Control equipment supplied by the Brush Electrical Engineering Company, Ltd., is designed for multi-unit operation and provides pneumatic control for diesel engine speed with electrical control of other equipment on the locomotive. Both the engine and the locomotive are protected against overspeed, and other protective devices incorporated in the control system cover lubricating oil, cooling water and transmission oil temperature. A "Serck-Behr" cooling equipment incorporates header tanks and is fitted with a fan driven by a hydraulic motor. This system supplies the cooling water for the engine, intercoolers and transmission heat exchanger. An oil-fired preheater is provided for raising the water temperature to an optimum figure before starting the engine.

The locomotive has a welded underframe and its cast steel "Commonwealth" type bogies supplied by the English Steel Corporation are of swing bolster design. The suspension system comprises triple elliptic spring nests between the equaliser beams and the bogie frame, with laminated springs under the bolster.

Vacuum braking is provided for the train and the compressed air braking equipment for the locomotive is controlled by the vacuum brake valve, or independently through a straight air brake valve. The braking equipment, supplied by Laycock Engineering, Ltd., has one compressor and two motor-driven "Northey" exhausters made by Gresham and Craven, Ltd.



1700 h.p. type 3 diesel hydraulic locomotive for British Railways

Industrial Electrical Air Filters

THE "Trion" electronic air filter, marketed since 1956 by W. C. Holmes and Co., Ltd., Turnbridge, Huddersfield, Yorks, has recently been redesigned to suit the arduous operating conditions met in industry, and in future it will be known as the "Industrion" electrical air filter. Its principle of operation is unchanged. The incoming particles of air are electrically charged (+ve) as they pass through the high-voltage ionising section of the equipment. Then, in the collecting section of the filter, the positively charged particles are attracted to the negatively charged elements of the electrostatic field set up between a series of parallel plates. Removal of dirt accumulated on the collecting plates is done periodically by switching off the power and opening a valve to spray the plates with water. Excitation supplies for the filter are taken from a power unit which provides 13,000V, d.c., for the ionising section and 6500V, d.c., for the collecting section.

"Industrion" air filters are designed to remove all particulate matter (from about 60 microns to 0·001 microns in size) from air and gas streams. Capacities range from 250 cubic feet per minute upwards; the power consumption is about 100W to clean 10,000 cubic feet per minute; the pressure drop is constant, the maximum value being about 0·2in w.g.

Each filter consists of one or more ionising collecting cells, a supporting framework, an after-baffle, a washing system and the associated electrical equipment.

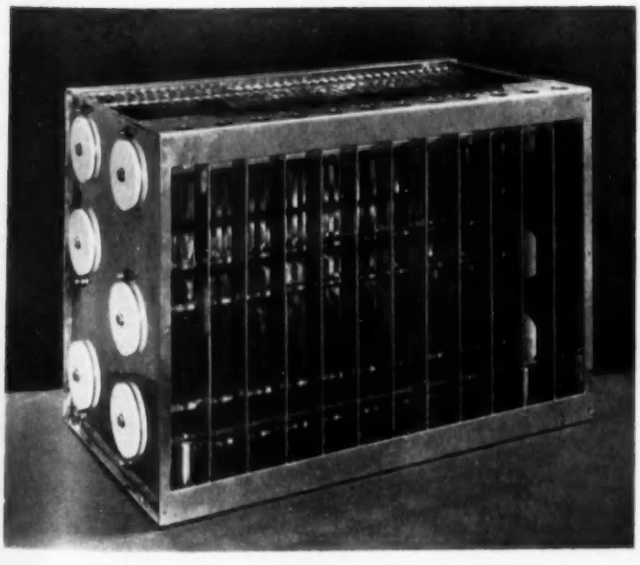
The standard ionising-collecting cells are made in two sizes, designed to meet most dimensional requirements in the assembled filter banks, and they are made from aluminium of heavier gauge than was used in the "Trion" filters. Other improvements include strengthened forms of supporting framework and ionising section support bars.

According to the application, the ionising section may consist either of finer tungsten wires or of points charged at 13,000V and supported between plate electrodes in an arrangement designed to give maximum ionisation with minimum resistance to air flow. In the collecting section the assembly of heavy gauge aluminium plates of alternate polarity is firmly supported on insulators which are positioned out of the air stream and are arranged to be cleaned by the built-in washing system. On the outlet side of the aluminium framework, just behind the collecting section, are the after baffle panels of washable nylon mesh. These panels prevent carryover of water during washing and they act as a barrier against blow-off of agglomerated dust if the filter has been allowed to become too dirty. Normally the washing system is fitted on the inlet side of the filter. It sprays the whole of the filter, but if continuous operation is required during cleaning, arrangements can be made to isolate a section of the filter.

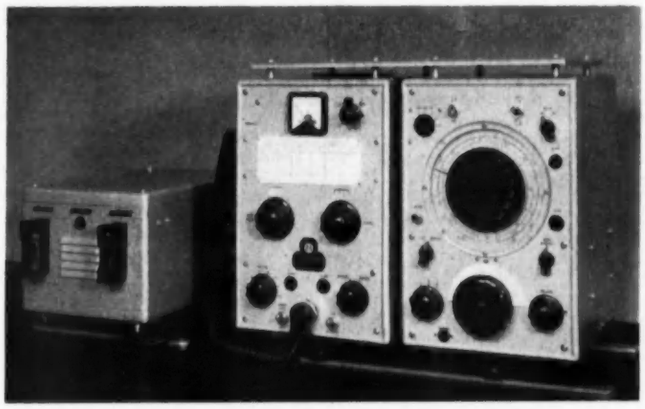
The standard range of filter consists of three models, each built up from standard cells. One of the filters (model 8) is uncased and is suitable for installation in a brickwork housing. The other two (models 7 and 9) are contained in a fabricated sheet-metal casing which can be of weatherproof construction, if required.

All the electrical equipment used in association with the air filters is supplied by the Electric Construction Company, Ltd., Wolverhampton. It consists, basically, of a rectifier with control cubicle, the dual output voltages of 13,000V and 6500V being derived from a high-voltage transformer and voltage doubling circuit. Current limitation and overload circuit breakers are provided to protect the equipment in the event of a short circuit. The high-voltage output is easily adjustable to suit the load and variations in mains voltage. All installations include an interlocked Castell-key-operated main isolator.

[Reply Card No. E8751]



Ionising collecting cell (capacity 2000 cubic feet per minute) of the "Industrion" electrical air filter



Power unit and transmitter/receiver of marine radiotelephone installation

Radiotelephone for Small Craft

INCREASING use is being made of radiotelephony for direct communication between ships and the inland telephone network. In order to bring these facilities into the range of small craft which are not obliged to carry radio, and where both space and power supplies are restricted, The Marconi International Marine Communication Company, Ltd., Marconi House, Chelmsford, Essex, has introduced the "Kestrel" transmitter/receiver installation. Facilities for visual "Consol" d/f and for loop d/f are provided in the receiver, which may be used either in conjunction with a goniometer unit and fixed loop, or with a rotating loop. As seen in the illustration, the transmitter and receiver units are of similar dimensions and can be mounted either side-by-side or one on top of the other to fit the space available.

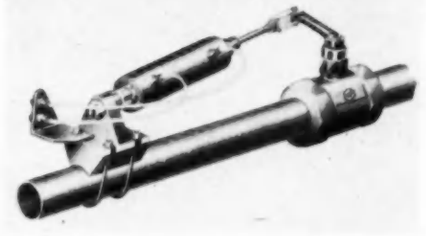
The receiver covers a frequency band of 190–4500 kc/s. The transmitter works on eleven spot frequencies in the band 1·6/3·8 Mc/s and can be operated on either the duplex or simplex system. The setting of the "Calling and Distress" frequency, 2182 kc/s, is clearly marked on the controls of both the transmitter and receiver. Metering facilities enable valve feeds, l.t. and h.t. supplies and "Consol" reception to be checked.

The power unit may be installed in any convenient position, beside or away from the transmitter and receiver, and draws its supply from either 24V or 12V batteries. The installation will deliver an output of 36W to 50W into a wire aerial of 60ft to 110ft or a whip aerial of about 20ft in length, although in the latter case the frequency range is limited to the band 2–3·8 Mc/s, with some reduction in radiation efficiency.

[Reply Card No. E8752]

Valve and Remote Control Assembly

A REMOTE control assembly complete with a "Fullway" valve is now available as a unit from Hydraulics and Pneumatics, Ltd., Villiers Street, Wolverhampton. A typical assembly, such as is shown in our illustration, comprises a double acting pneumatic or hydraulic cylinder anchored to the pipeline by a bracket and having its piston-rod pivotally connected to the valve lever. The flexible pipes supplying power fluid to the cylinder terminate in a plate on the bracket through which they are coupled by unions to the power source control unit.



Valve with its remote control cylinder fitted on a pipe

If required a complete valve and operating assembly can be supplied as a packaged unit mounted on a standard length of pipe. The valves available with this control range from ¼in diameter for a maximum working pressure of 3600 lb per square inch to 8in diameter for pressures up to 140 lb per square inch, and multi-way valves from ¼in to 1¼in diameter can also be fitted.

[Reply Card No. E8753]

SHORTER REPORTS *(continued)*

Packaged Substations with Air-Cooled Transformers

FOR handling electricity supplies to extensions which have been made to the cold storage plant of T. Wall and Sons (Meat and Handy Foods), Ltd., of Willesden, London, Ferranti, Ltd., Hollinwood, Lancs, has supplied two 1000kVA, 6·6kV/415V, class-C-insulated air-cooled transformers, with associated medium-voltage isolators, instruments and control equipment to form indoor packaged substations. The manufacture of these self-contained units marks the company's entry into the packaged substation field. In this installation, however, development has been taken a stage further in that the transformers are directly coupled through off-load isolators, to the busbars of a multi-starter contactor switchboard, manufactured by Morecambe Electrical Equipment Company, Ltd. The switchboard is designed to control ammonia compressor motors which total about 2000 b.h.p. The transformers are installed at each end of the multi-starter panel and with it form a composite switchboard which is installed on a gallery in the compressor hall approximately 9ft above floor level. Outgoing feeders from fuse switches which also form part of the switchboard supply ancillary plant and services in the compressor hall and adjacent cold store block.

High-voltage switchgear controlling the incoming 6·6kV feeders to the transformers is located in an existing substation, but can be controlled from the transformers by means of remote control of solenoid closing mechanisms. Restricted earth-fault protection of the transformer medium-voltage windings is provided by instantaneous relays, mounted on the transformers, which trip the associated h.v. switches. The transformers are totally enclosed and busbars are used to connect all cubicles. Therefore cable faults are eliminated and the whole construction is robust.

The chief merits of self-contained units of this kind are that they can be installed as near as possible to the load centre of the plant, giving considerable saving in low-voltage cabling costs, cable losses and voltage drop. Building and maintenance costs are also kept down and fire protection is unnecessary because no oil is involved.

As can be seen from the right-hand illustration the transformer is mounted on rollers running in guide rails within the cubicle, the rear of which is removable, to facilitate removal of core and windings for inspection and maintenance when required. A cooling air inlet is located at the base of the transformer cubicle and air is ducted from outside the building through a filter.

Each isolator cubicle, which is positioned between each transformer cubicle and the starter board, consists of an off-load isolator, control panel and terminal chamber. An isolator having a continuous rating of 1600A is chassis-mounted in the centre of the cubicle; access to it being by means of a hinged door. It is manually operated from the front and is equipped with a safety electrical interlock arranged to trip the associated high-voltage circuit breaker if any attempt is made to open the isolator on load. In addition Castell-key interlocking is provided between the isolators and bus-section switch so that the latter cannot be closed unless one of the transformer incoming switches is open. Although the switchboard will normally be operated with the bus-section switch open, the reactance of the transformers was selected to limit the fault level on the medium-voltage busbars to 30MVA when the transformers are paralleled. Sectionalising will also enable a spare transformer of standard reactance to supply one-half of the switchboard if necessary under emergency conditions. All contactor starters are "backed-up" by h.r.c. fuses to achieve a fault rating of 30MVA at 415V.

The combined class-C transformer/motor starter board is believed to be the first of its kind made in the United Kingdom. The complete scheme which was designed by Unilever, Ltd., Technical Division, London, in conjunction with Ferranti, Ltd., and Morecambe Electrical Equipment Company, Ltd., meets the requirements of the Factories Acts concerning ammonia explosion hazards, obviates the need for a separate substation and is the most economical method of providing a supply for this particular duty.

[Reply Card No. E8761]

Work Clamping Devices

A RANGE of hydraulic vice jaws and clamping fixtures, designed and manufactured by Larrad (Hydrajaws), Ltd., is now distributed in this country by Alfred Herbert, Ltd., Coventry. The "Hydrajaws" as they are known, consist of mild-steel blocks, suitable for inserting in a machine vice, and the blocks have a series of protruding plungers with which the workpiece is gripped. Interconnection of spaces filled with hydraulic oil behind the plungers enables the

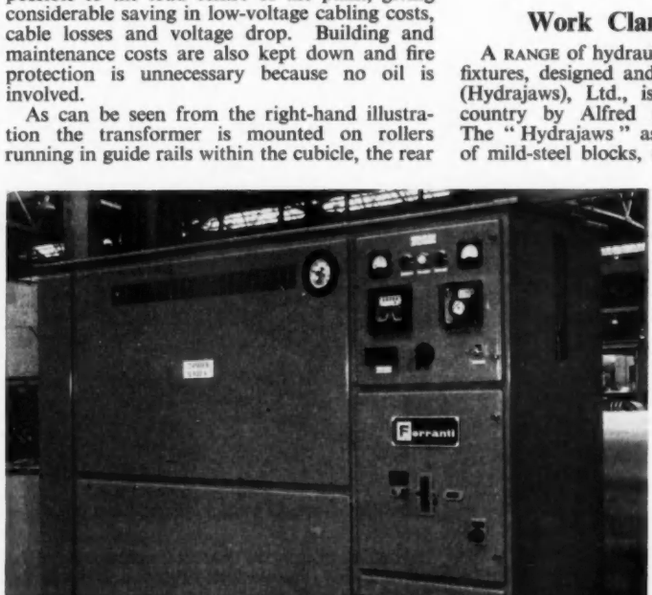
Standard hydraulic jaw fitted with conical plungers for use in a machine vice

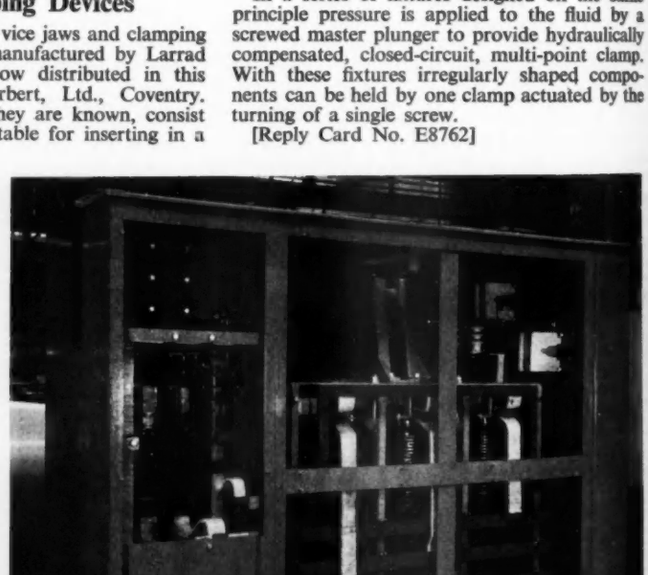
plungers to adjust themselves automatically to the contour of the workpiece as the vice is being closed and also to exert equal pressures when the vice is fully tightened. In practice it has been found that, in addition to applying equal pressures, the clamping effort of each plunger when the vice is only moderately tightened, is greatly in excess of that applied by the vice jaws alone.

Eight standard models of jaws, such as that shown in our illustration, are available with a choice of six designs of plunger heads. Smaller sizes of "Hydrajaws" can be supplied with matching multiple-vee blocks, suitable for holding a number of small components, or with blocks having a single horizontal vee. Also being made are six sizes of clamps which operate on the same principle as the "Hydrajaw" blocks and resemble conventional solid jig-and-fixture clamps. In place of the normal solid clamping pads there is a row of clamping plungers, again interconnected by hydraulic oil giving fully compensated clamping.

In a series of fixtures designed on the same principle pressure is applied to the fluid by a screwed master plunger to provide hydraulically compensated, closed-circuit, multi-point clamp. With these fixtures irregularly shaped components can be held by one clamp actuated by the turning of a single screw.

[Reply Card No. E8762]





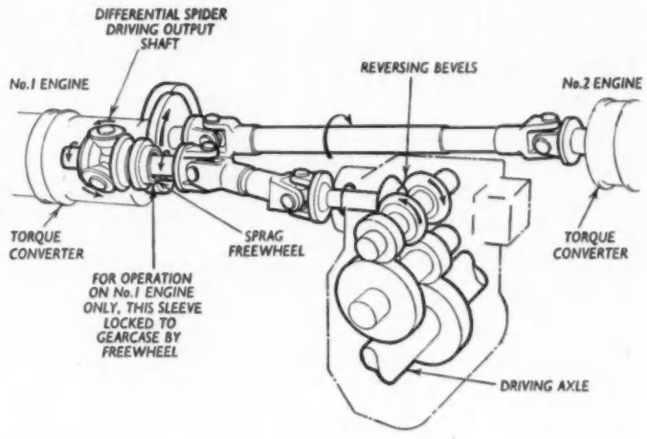
Packaged substation (one of two) for a London cold storage depot. Each substation contains a Ferranti 1000kVA, 6·6kV/415V class-C insulated transformer with medium-voltage isolators, instruments and control equipment; (right) with covers removed

600 h.p. Diesel-Hydraulic Locomotive

A 600 h.p. DIESEL-HYDRAULIC locomotive developed by the Yorkshire Engine Company, Ltd., in collaboration with Rolls-Royce, Ltd., is designed to combine a capacity for heavy shunting duties with a capacity for long-haul freight train working at speeds up to 36 m.p.h. The prototype of this new "Taurus" design locomotive, as it is known, is at present undergoing trials on British Railways. It is powered by two Rolls-Royce engines each developing 311 h.p. at 1800 r.p.m. and driving through a summating transmission recently introduced by that firm and called the "S" type. With this transmission the locomotive with one engine driving can give its full tractive effort for heavy low-speed shunting duties. When higher rail speeds are required for trip working the second engine can be engaged without a break in torque and the driver does no changing of gears. The "Taurus" weighs 58 tons and its maximum tractive effort is 45,000 lb, the continuous working range being 1 to 11½ m.p.h. on one engine and 6 to 36 m.p.h. on two engines.

In this new design of locomotive two moderately rated engines are installed in opposed positions, one on each side of the centrally disposed driver's cab, and they drive through torque converters into a differential gearbox as shown in the diagram we reproduce. This differential gearbox is mounted at the rear of No. 1 power unit and from it a cardan shaft drives a final gearbox mounted on one of the intermediate axles. The second engine, used when higher rail speeds are required, drives through a cardan shaft to the differential at an input ratio of 1·88 : 1. When it is introduced it takes its share of the load at all speeds above about 3½ m.p.h. In this way one engine can give a high starting tractive effort depending upon gear ratio and wheel diameter.

A friction clutch between the No. 1 engine and torque converter assembly has an over-centre mechanism and permits the drive to be disengaged for starting, idling and testing purposes. The No. 2 power unit has two oil-operated clutches, one of which is engaged for converter drive and the second to provide a direct drive at the higher track speeds: its drive is transmitted through a single spur gear train which changes the direction of rotation and provides an increase in input speed. Output from the differential is taken from the spider carrying the three planetary bevel wheels; the main bevel driven by No. 2 engine is prevented from rotation by a sprag design free-wheel when the other engine alone is under power. The final drive gearbox on the driving axle contains three stages of reduction gearing, the first stage of which is a spiral bevel group incorporating reversing mechanism engaged by an air-operated sliding dog.

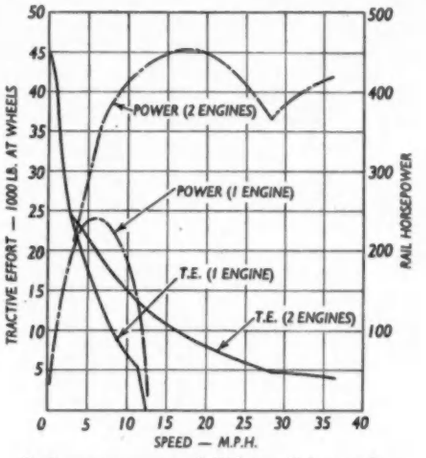


Principle of operation of type "S" transmission as fitted to diesel-hydraulic locomotive

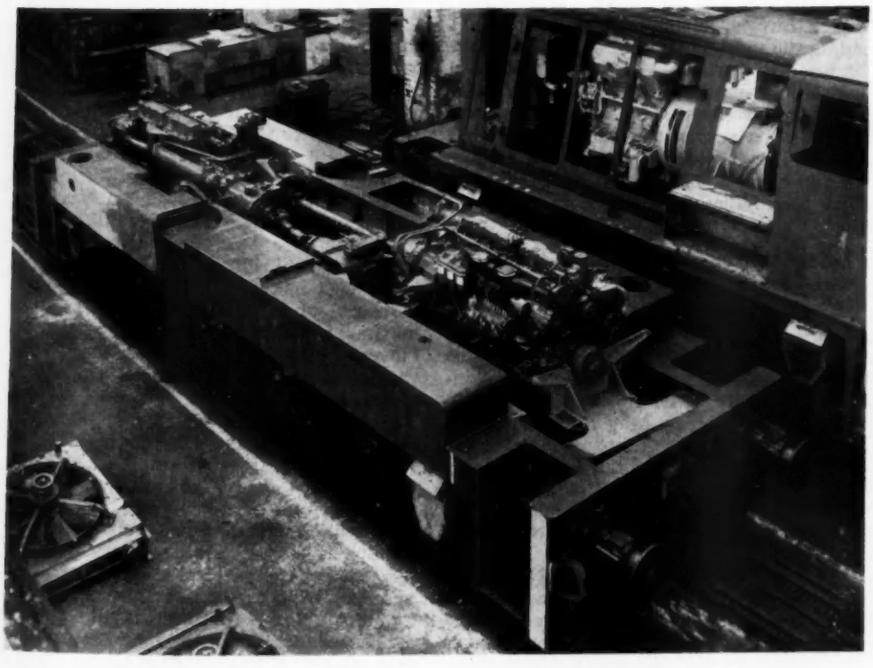
The performance of the locomotive is shown in the graph on this page. Operating efficiency will be seen to be good in terms of wheel horsepower available from one engine up to more than 5 h.p., and from both engines at the higher speeds.

Under the control system No. 1 engine is started with its clutch in neutral and movement of the throttle lever to the idling position engages its clutch, further movement of the lever progressively increases the power to give the maximum tractive effort at start and, in this case, a maximum speed of about 12 m.p.h. The second engine can be brought into service at any position of the throttle by operation of a second lever, after which its power is controlled by the same throttle lever as the first engine. At a speed of about 29 m.p.h. an automatic control engages the direct drive clutch in the No. 2 power unit.

The locomotive has bar steel side frames bolted together with welded stretchers and heavy steel buffer beams, the beams being extended down to protect the final drive gearbox from damage in the event of derailment. Overhung springs located in pockets in the frames can easily be adjusted or replaced. Roller bearing axleboxes are fitted and, with their guides, are lined with manganese steel requiring no lubrication. The 3ft 9in diameter wheels are all coupled by forged and machined rods fitted with leaded phosphor bronze brakes. Westinghouse vacuum-controlled air brake equipment provided incorporates means whereby train brake application will apply the locomotive air brake proportionally. A Broom and Wade air compressor is driven from No. 1 engine and vacuum for the train brake is provided by an independent rotary exhauster driven by a Lister air-cooled diesel engine.


TRACTIVE EFFORT — 1000 LB. AT WHEELS
RAIL HORSEPOWER
SPEED — M.P.H.
POWER (2 ENGINES)
POWER (1 ENGINE)
T.E. (1 ENGINE)
T.E. (2 ENGINES)
0 5 10 15 20 25 30 35 40
5 10 15 20 25 30 35 40 45 50
100 200 300 400 500

Performance curves of "Taurus" locomotive



Frame of "Taurus" 600 h.p. diesel-hydraulic locomotive with engines and transmission installed

Thermal Insulation of Steel Chimneys

THE heat loss inherent with a steel chimney results in the condensation of flue gases on the comparatively cool surfaces to form a corrosive acidic solution. This not only attacks the metal but the acid film aggregates carbon particles which may be emitted as acidic smuts. To prevent this condition obtaining, chimneys have been clad with aluminium sheet to act as a thermal shield. This treatment maintains the chimney walls above condensation point and the flue gases at a higher temperature so that the velocity of emission is high and the gases are more easily dispersed. F. E. Beaumont, Ltd., Rathgar Road, London, S.W.9, has been engaged cladding stacks since May, 1959, using 16 gauge aluminium sheet, supplied by the British Aluminium Company, Ltd. The following are the results obtained from one of the many stacks fitted with aluminium cladding. The stack is 16in diameter by 40ft high and when unlagged the metal temperature immediately above the boiler outlet was 350 deg. to 375 deg. Fah., and at the top was about 125 deg. Fah., representing a temperature drop of 225 deg. to 250 deg. Fah. After lagging the stack the temperature of the metal at the boiler outlet was 350 deg. to 375 deg. Fah. and the temperature at the top was 275 deg. to 288 deg. Fah., indicating a drop in temperature of the order of 75 deg. Fah. Thus the metal of the stack is at a temperature which renders the possibility of condensation almost negligible.

INDUSTRIAL NEWS

Spring-Making Research

At the recent conference of the Coil Spring Federation, Mr. Robert Salter Bache, the President, drew attention to the need for making use of the information provided by the research workers in the place where it could do most good—on the shop floor. That could only be done by individual managements. Mr. Bache said, "We cannot expect the research team to do this work for us—they can only provide us with the tools, and it is up to us to make use of them. In this competitive struggle there is no doubt that co-operative research is the most economic method for any individual company to obtain scientific development."

The Coil Spring Federation Research Organisation has already put into practice the President's suggestion and has, in fact, had for the last twelve months an industrial liaison officer, Mr. Henry Snow, operating from its Sheffield laboratories. It is Mr. Snow's duty both to interpret research results and to report back with industrial problems. One of the results of this work has been a shift in the emphasis of the research programme towards production problems in response to requests for more work directly connected with the shop floor. It is emphasised that maximum help to the production side can only be given if the problem is clearly defined.

A typical problem being investigated is that of overcoming the difficulty of coiling springs of high index made from phosphor bronze wire. When the curvature required by the wire is such that the material is not strained very far beyond its elastic limit, a considerable variation in spring dimensions can occur. The Organisation's laboratories, a spring manufacturer, a phosphor bronze wire maker and the British Non-Ferrous Metals Research Association are working together in an effort to solve this problem, which is basically one of production. Another production problem is the need to develop an automatic spring-coiling machine. After considerable preliminary liaison work by the C.S.F.R.O., a well-known machine tool manufacturer has agreed to develop such a machine at his own financial risk. These and other projects are proving the practical value of the Organisation's efforts to apply research, but the Director of Research, Mr. Ronald Haynes, reported that it is still doubtful whether the accumulated knowledge is being used to the best advantage. One of the ways in which an improvement might be made is to employ a technical information officer, and the need for such an appointment was put forward at the conference.

Investment of Foreign Capital in Finland

The Finnish Embassy, 66, Chester Square, London, S.W.1, has issued a note on the investment of foreign capital in Finland. It is generally recognised in that country that foreign capital is desirable for the development of industrial projects and the use of natural resources for manufacturing purposes. The foreigner who is considering the possibility of investing money in Finland has to take into account a number of special factors. Finland, it is of interest to note, is a country with particularly small foreign debts. On a *per capita* basis the country's long-term liabilities are probably among the smallest in the world. A favourable factor is the high reputation which Finland has acquired as a country which pays its debts. The interest level there, too, is usually relatively high, which is an added attraction for investment.

There are legal requirements covering the establishment and operation of foreign companies, whether partnerships or joint stock companies, ownership of shares in Finnish companies, and membership of boards of directors. Corporate taxation is fixed at present at 38 per cent of taxable income, with a reduced scale in respect of incomes below Mk. 700,000, but this is under Parliamentary review. In addition, a local tax is paid, varying between 8 and 15 per cent according to district, and a tax of about 1 per cent of taxable income is paid to the church. Special tax advantages are offered to new industries in the north of Finland, and arrangements have been made with a number of countries whereby double taxation is avoided. Allowances for depreciation are intricate, and subject to frequent amendment. There are regulations covering the repatriation and transfer of foreign assets and for the transfer of dividends.

In the matter of raw materials there is considerable capacity for expansion, especially in the timber industries which, in 1959, accounted for 75 per cent of the country's exports. It is calculated that the reserves of raw materials are equal to about 2,000,000 tons of cellulose annually; in round figures this is equivalent to doubling the production of cellulose. Labour is plentiful and will be for some years to come and wages are lower in Finland than in many other countries, in spite of the fairly high standard of living.

The Finnish authorities have taken a much freer course in recent years in the matter of foreign investment, and they aim to offer alternatives which will give a prospective foreign investor a choice and a means of finding the most suitable form of investment for his own particular case. It is stressed that although the timber industries offer particular advantages, in view of the reserves of raw material, they are not the only ones which the authorities have in mind; there are numerous other fields in which Finland offers possibilities for useful investment.

Safety in Non-Ferrous Metals Production and Casting

Requirements for the protection of workers engaged in the melting or founding of non-ferrous metals are proposed in the revised preliminary draft of the Non-ferrous Metals (Melting and Founding) Regulations issued on May 16, 1961, by the Ministry of Labour. These regulations are based on the Report of the Joint Standing Committee on Safety, Health and Welfare Conditions in Non-ferrous Foundries. The first preliminary draft of the regulations (then entitled "The Non-ferrous Foundries Regulations") was published in November, 1959, and contained a general invitation to make comments on the proposed regulations.

The text now issued has been prepared in the light of the numerous observations received and of consultations held with organisations of employers, workers and other interested parties. The major change has been the inclusion within the regulations of that part of industry dealing with the melting and casting of metal for the production of non-ferrous ingots, billets, slabs and other similar non-ferrous products and a consequent amendment of the title to meet the revised scope of the regulations. Copies of the draft Regulations may be obtained from the Ministry of Labour, Safety, Health and Welfare Department (W.5), 19, St. James's Square, S.W.1. Any observations on these draft Regulations should be made in writing to the Ministry of Labour, at the above address, by August 31, 1961.

Shipping Freight Index

The Chamber of Shipping of the United Kingdom has announced that changes in the pattern of trade during recent years have made it necessary to adopt a new basis for the index of tramp shipping freights. The revised index number has been calculated by references to the average freights in 1960, instead of 1952 as hitherto, and the pattern of trade used is that shown by the invisible exports inquiry. The commodities used in the revised calculations are those which represent more than 93 per cent of the total freight earnings on voyage charter and are the same as those previously used except that esparto is excluded and sulphur brought in. Although the commodity list shows little change there are, however, differences in weightings, in particular a reduction for coal and a big increase for fertilisers. Freights in 1960 were considerably lower than in 1952 and the average index number for 1960 to the base 1952=100 was 74·2 so that the index numbers on the new basis of 1960=100 are correspondingly higher.

Request for Increased Iron and Steel Prices

The executive committee of the British Iron and Steel Federation recently considered the earnings position of the industry. Since September, 1960, when coal prices were increased, the industry's costs have risen by about £40,000,000 a year. Even taking earlier cost savings into account, the net cost increase over the past year has amounted to some £30,000,000. This is equivalent to well over 30s. a ton of finished steel. Steel companies have not been free to adjust their prices in face of such heavy cost increases, as have other private industries and nationalised concerns, since maximum steel prices are fixed by the Government-appointed Iron and Steel Board, which has not yet seen fit to sanction price increases.

As a result, earnings in the industry have been under increasing strain for months past. In this respect, regard must be had to the fact that steel companies have been planning a record level of development expenditure this year, amounting to well over £200 million. The Executive Committee expressed it's deep concern over the present position and decided to repeat its request to the Iron and Steel Board to consider authorising a significant increase in maximum home trade prices for iron and steel products.

PERSONAL AND BUSINESS

Appointments

SHELL-MEX AND B.P., Ltd., announces that Mr. C. M. Vignoles, managing director, is retiring on June 30 and is to be succeeded by Mr. J. E. H. Davies.

COMMANDER F. HOLMES has been appointed a director of the Westrex Company, Ltd., a division of Litton Industries Inc., of the U.S.A., with responsibility for sales.

THE MINISTER OF TRANSPORT, the Rt. Hon. Ernest Marples, M.P., has re-appointed Sir Philip Warter to be a part-time Member of the British Transport Commission until May 31, 1962.

MR. F. M. FIELDHOUSE has been appointed group traffic manager by British Ropes, Ltd., of Doncaster and branches. He was formerly with the Tarmac Group as transport manager of Tarmac Roadstone, Ltd.

WESTERN REGION, BRITISH RAILWAYS, has announced that Mr. G. W. Robson, A.M.I.Mech.E., M.I.Loco.E., assistant running and maintenance officer, has been appointed assistant general manager with duties in the sphere of modernisation.

MR. E. JARMAN, M.I.Mech.E., F.Inst.Pet., has joined the Council of British Manufacturers of Petroleum Equipment as technical adviser, having relinquished his post as Head of the Mechanical Engineering Division of the Kuwait Oil Company, which he has held since 1947.

MR. C. R. BATES, A.M.I.E.E., A.M.Brit.I.R.E., has been appointed a director, sales and service, of the Canadian Division of the Weltronic Company. Mr. Bates will handle the Weltronic range of controls for resistance welding from 60a, Station Road, Solihull, Warwickshire (Tel. SOLihull 5276).

WILLIAM DENNY AND BROTHERS, Ltd., announces that Mr. E. L. Denny has become President and has been succeeded as chairman of the company by Mr. W. D. K. Marshall. Mr. F. R. Topping has been appointed deputy chairman and Mr. C. F. Morris, the company's naval architect, has been appointed a director.

THE WATER-TUBE BOILERMAKERS' ASSOCIATION states that Mr. H. McNeill, managing director of Babcock and Wilcox, Ltd., has been appointed chairman of the Association in succession to Mr. J. B. Woodeson, chairman of Clarke, Chapman and Co., Ltd., who has completed a period of four years as the Association chairman.

Business Announcements

DOW AGROCHEMICALS, Ltd., King's Lynn, has appointed Agroup, Ltd., Tunbridge, as its press and public relations consultants.

THE LEAD DEVELOPMENT ASSOCIATION has moved from its offices at 18, Adam Street, London, W.C.2, to 34, Berkeley Square, London, W.1. (telephone, Grosvenor 8422).

MR. R. S. GILLING, B.Sc., A.M.I.E.E., A.M.I.W.M., has been appointed manager of the Associated Electrical Industries, Ltd., Military and Marine Radar Works at Blackbird Road, Leicester.

L.M.B. COMPONENTS, Ltd., Weyford House, Woodbridge Meadows, Guildford, Surrey, announces that it has decided to relinquish the position of sole United Kingdom distributor for Projecteurs Cibie.

E. GREEN AND SON, Ltd., Wakefield, Yorks, announces its appointment as sole licensees in the United Kingdom for the manufacture of Sinter fans and Schicht axial blowers designed by Kuhnle, Kopp and Kausch, Frankenthal.

LANDMASTER, Ltd., Stornoway House, Cleveland Row, London, S.W.1 (a member of the Firth Cleveland Group), is now offering its tractor-mounted rotary tiller in the general export market, in accordance with an expansion programme.

HILGER AND WATTS, Ltd., 98, St. Pancras Way, London, N.W.1, announces that Wray (Optical Works), Ltd., has come into association with it. Mr. A. W. Smith (a former President of S.I.M.A.) is continuing as managing director of Wray (Optical Works), Ltd.

IN connection with the fusion of the British Cotton Industry Research Association and the British Rayon Research Association, the former organisation has changed its name to the Cotton, Silk and Man-Made Fibres Research Association (Shirley Institute). Its address will continue to be Shirley Institute, Didsbury, Manchester, 20 (telephone, Didsbury 8811/5).

MATCHLESS MACHINES, Ltd., TESA Division, 18, Bolton Street, London, W.1, states that the following companies have been appointed area distributors for "TESA" high precision measuring equipment: Stuarts and Houston, 5, York Street, Glasgow, C.2, for the whole of Scotland, and Batesons, Ltd., 105-111, Yorkshire Street, Rochdale, for Rochdale and the surrounding area.

GOODYEAR PUMPS, Ltd., has moved its Sales and Service Division to larger offices at Walmgate Road, Perivale, Middlesex (telephone, Alperton 1132-3). The Division remains under the control of the general sales manager, Mr. E. H. Curry. A West End office is being retained at 44, Brook Street, London, W.1, the London headquarters of the Goodyear parent company, Holman Brothers, Ltd.

L. SCHULER A.G., Goeppingen, Wuertt, Germany, and WICKMAN, Ltd., Conventry, announce the formation of a jointly owned British company, Schuler Presses, Ltd. The new company has been formed to establish the manufacture of certain Schuler presses in the United Kingdom and to provide a U.K. based engineering and after-sales service to Schuler press users. Wickman, Ltd., will act as exclusive sales representative for these presses.

WHITFIELD INDUSTRIAL DEVELOPMENTS, Ltd., of Woolston, Southampton, announces to-day that the Diamond Power Specialty Corporation of Lancaster, Ohio, U.S.A., has acquired its three subsidiary companies, the Diamond Blower Company, Ltd., Ferry-Diamond Engineering Company, Ltd., and Fyrex, Ltd. These three companies are all engaged in the engineering field and manufacture boiler cleaning plant, pumps, filtration plant and fire-fighting equipment.

SPERRY GYROSCOPE COMPANY, Ltd., Great West Road, Brentford, Middlesex, to-day announces that Mr. Robert G. Hess is to become managing director, in place of Mr. Robert Broadbent, who continues to serve on the Board of Directors. The purpose of the change, which involves a temporary appointment only for Mr. Hess, is to strengthen the direct co-operation between the London and New York companies and to achieve increased efficiency and competitiveness in Export Markets.

AN analogue computation centre to serve industries in the United Kingdom has been established near London by Electronic Associates, Ltd., wholly owned subsidiary of Electronic Associates, Inc. The new installation, known as the United Kingdom Computation Centre, is located at the Burgess Hill manufacturing plant of E.A., Ltd., and is available on a time-rental basis for design and simulation programmes in nuclear, automotive, missile, chemical and shipbuilding fields.

RENOLD CHAINS, Ltd., Wythenshawe, Manchester, has moved the headquarters of its Belgian branch, operated by Renold Chains Continental, Ltd., to 1, Allee Verte, Brussels. This new three-storey building has an area of over 20,000 square feet, and there is a sub-basement housing a plant for the manufacture of bespoke wheels. Large stocks of chains and wheels for power transmission and mechanical handling and for cycles, motorcycles and cars are held in the new premises.

INTERNATIONAL COMPUTERS AND TABULATORS, Ltd., Gloucester House, 149, Park Lane, London, W.1, and the NATIONAL DATA PROCESSING CORPORATION of Dallas, Texas, U.S.A., announce a long-term marketing and manufacturing agreement. National Data Processing Corporation are manufacturers of document handling equipment, initially designed for bank automation, and optical character recognition equipment. By the agreement N.D.P. products will shortly be added to the I.C.T. range of equipment.

MR. ERNEST MARPLES, Minister of Transport, answering a question in the House of Commons, announced the membership of the Committee appointed, under the chairmanship of Lord Rochdale, O.B.E., T.D., to inquire into the major docks and harbours of Great Britain. The other members will be Mr. J. Maurice Laing, Mr. Ian W. Macdonald, Mr. E. G. Whittaker and Mr. Richard Wills. The Committee will have the advice of Sir Eric Millbourn, C.M.G., Honorary Adviser to the Minister on Shipping in Port.

JOHNSON MATTHEY AND CO., Ltd., announces important developments in connection with its work on germanium. Zone-refined (50Ω-cm, n-type) germanium is now available, normally in ingots having a nominal weight of 1 kg. A large scrap-recovery plant has been installed which enables a wide variety of types of germanium-bearing residue to be processed. The company now wishes to purchase large or small quantities of germanium scrap, and will be pleased to hear from any organisation having such material for disposal.

A. REYROLLE AND CO., Ltd., Hebburn, Co. Durham, announces agreements with Oliver J. Nilsen (Australia), Ltd., for collaboration in the manufacture of high-voltage switchgear and ancillary equipment in Australia. It is proposed to form a new company, Reyrolle Nilson (Australia) Pty., Ltd., with an authorised capital of £500,000, and register the office at 45, Bourke Street, Melbourne, Victoria. Progressive stages of manufacture will be undertaken at a factory to be set up in Melbourne, and staffed with a nucleus of Hebburn trained personnel.

SOCIETE ANONYME DES ETABLISSMENTS ED. JAEGER, of Paris, has accepted an invitation to become the sole representatives for Metropolitan France for Smiths Aircraft Instruments, Ltd. An agreement between the two companies covers the sales and servicing in France of the complete range of aviation instruments and equipment, including the products of Smiths' associates, Kelvin and Hughes (Aviation), Ltd., and Waymouth Gauges and Instruments, Ltd. It excludes spark plugs, igniters and jet pipe temperature measuring equipment, which will continue to be handled in France by Smiths' associate there, K.L.G. Soc. Anon.

Contracts

CARGOCAIRE, Ltd., has received an order to install its dehumidification and ventilation system in nine 12,000-ton ships under construction at Wärtsilä Koncernen, Oslo, Finland.

SOCIETE GENEVOISE D'INSTRUMENTS DE PHYSIQUE, of Switzerland, has placed an order worth approximately £20,000 with E.M.I. Electronics, Ltd., for six E.M.I. rotary control systems to fit "Rotoptic" rotary positioning tables.

W. H. ALLEN, SONS AND CO., Ltd., has contracted to supply a total of twelve diesel-driven generators for four cargo ships presently building for Alfred Holt and Co., Ltd. There are three units for installation in each ship and each unit consists of a 500kW, 220V generator, driven at 450 r.p.m. by an Allen BS.37-D. four-stroke diesel engine.

THE CLAYTON EQUIPMENT COMPANY, Ltd., Halton, Derby, a member of the International Combustion (Holdings), Ltd., Group, has received an order worth approximately £5,000,000 for eighty-eight type-1 diesel-electric locomotives. These locomotives will have a central cab and twin generating sets, one at each end. They will be able to operate on one or both generators. Two Paxman engines, each of 450 h.p. will be fitted, and the electrical equipment will be supplied by The General Electric Company, Ltd.

SOUND DIFFUSION (AUTOTHERMATIC), Ltd., has received a contract from Sir W. G. Armstrong Whitworth Aircraft, Ltd., for automatic fire detection equipment in the main factory groups at Baginton, Whitley and Bitteswell. The contract, believed to be the largest single contract ever placed for fire detection equipment, when finished is expected to contain over 13 miles of break link cable detectors, representing over 23,600 detection points, plus a further 880 unit detector heads situated in offices and administrative areas, to cover a building area of some 2,000,000 square feet.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., has been awarded a contract worth about £1,750,000 by the Central Electricity Generating Board for the supply and installation of 132kV underground cables between the C.E.G.B. terminal tower at Lessness, Belvedere, and the substation at Wimbledon, over a route length of about 19 miles. The contract is due for completion in September, 1962. There will be two circuits, each of three single-core, oil-filled cables with 0·75 square inch copper conductors. One circuit will be sheathed with corrugated seamless aluminium and the other with reinforced lead. Control and communication cables will be installed beside the main power cables. The load capacity of the power cables will be 300MVA with both circuits loaded, or 170MVA with only one loaded. These new cables will provide a power link with two other major 132kV oil-filled cable installations which B.I.C.C. already has in hand for the C.E.G.B., between Kingston and Wimbledon and Kingston and Chessington.

Tata Power Jubilee

BY OUR INDIAN CORRESPONDENT

RECENTLY the Tata-Electric Power Supply Company, Ltd., celebrated its golden jubilee. Its progress during the past five decades makes interesting reading. The Tata System, which supplies power to the Bombay–Poona region, is one of the oldest and largest interconnected systems in India. Tata's operate four power stations in the region, three of which are hydro-electric installations, Fig. 1, and one is a thermal station. They are linked with the Railways' thermal power station at Chola. The total installed capacity of the system is approximately 600,000kW, and the peak load about 456MW. The company's power generation in 1959 exceeded 2500 million kWh, and sales to Tata consumers, 1893 million units. In terms of sales it is the largest utility company in India, and in terms of the cost of power one of the cheapest.

The Tata Hydro-Electric System serves an area in Maharashtra State of more than 800 square miles. It has a fixed capital expenditure in excess of Rs.30 crores, and an annual output representing more than a sixth of the total electricity production. The transmission network of the system consists of 582 circuit miles of 100,000V overhead lines and 9·4 miles of 100kV gas-filled underground cables, and distribution network of 141 circuit miles of 22,000V overhead as well as 104 miles of 11,000V overhead and 20 miles of 6600V overhead lines. The inter-connecting transmission lines of the railway add another 272 circuit miles to form the combined Tata Hydro-Railway Grid. Power is supplied to the textile mills and other industries of Bombay and the suburban areas, to local authorities, and, in bulk for retail distribution to the electricity undertakings supplying Greater Bombay, Poona and ten other localities within the area.

The Tata Hydro-Electric System had an intial generating capacity of 276MW comprising three hydro-electric stations at Bhira, Bhivpuri and Khopoli. This capacity together with the Railways' Chola thermal power station sufficed to meet the system requirements in respect of capacity and energy till the post-war period. Since then demands on the system have increased considerably due to rapid industrialisation, and the need for early augmentation of generating capacity was felt. The Tata Hydro-Electric Companies came to the conclusion that this could be best achieved by the installation of thermal generating units and, accordingly, two units each of 62·5MW capacity were planned for at Trombay.

The Trombay thermal power station, illustrated, is the most modern of its kind in India. Situated on a 132-acre land on the south shore of Trombay, 7 miles north-east of Bombay, it consists at present of three 62,500kW units, and the layout permits expansion to an ultimate four such units. The plant is of the outdoor type designed on the unit system basis with one boiler and one turbine per unit. The radiant type water-tube boilers are designed to burn refinery waste gas, oil and low grade coal. At present the boilers at the first two units are being fired with refinery pitch, while the third unit boiler is being fired with pulverised coal. Each of the boilers is capable of generating steam at a rate of 600,000 lb per hour at 1325 lb per square inch gauge and 955 deg. Fah. The steam from the boiler is delivered at 1250 lb per square inch gauge and 950 deg. Fah. to a twenty-two-stage, twin-cylinder impulse turbine, which exhausts the steam into a single shell two pass condenser at 2½in mercury absolute. The steam in the condenser is cooled by sea-water pumped from Bombay Harbour through a 4066ft long 72in diameter steel pipe projecting approximately 2000ft into the sea from the low water line. The condensed steam is fed back to boiler at 410 deg. Fah. after passing through five feed-water heaters. Each turbine drives a hydrogen-cooled 13·8kV, 50,000/62,500kW generator which is connected to the transmission grid through a 80,000kVA, 13·8/100kV transformer.

To cope with the operating problems in such an interconnected system Tata's inaugurated a load dispatch centre at Lonavla in 1951 to ensure optimum utilisation of the monsoon and storage waters during the year, but it did not take up the entire responsibility of switching operation and safety procedure. In 1956 just before starting of the first 62,500kW steam turbine generator at Trombay the load dispatch department was shifted to Trombay which was near the load centres also. The load dispatch office has a mimic board with a complete switching diagram of the system and normally operated switch position indicators.

To further improve the efficiency of the load despatch centre, Tata's are going in for the most modern means of communication suitable for the system. The new Power Line Carrier Current Equipment, which is on order, will provide a highly reliable telephony system between the load despatch office and all stations and will also provide continuous monitoring of important system parameters like generated MWs and MVARs at all stations and the h.t. bus voltages at important stations. It is expected to cost about Rs.23 lakhs, of which the major equipment will be supplied by the Brown Boveri Company of Switzerland, Siemens of Germany and the General Electric Company of U.S.A. The installations are planned to be completed in 1962.

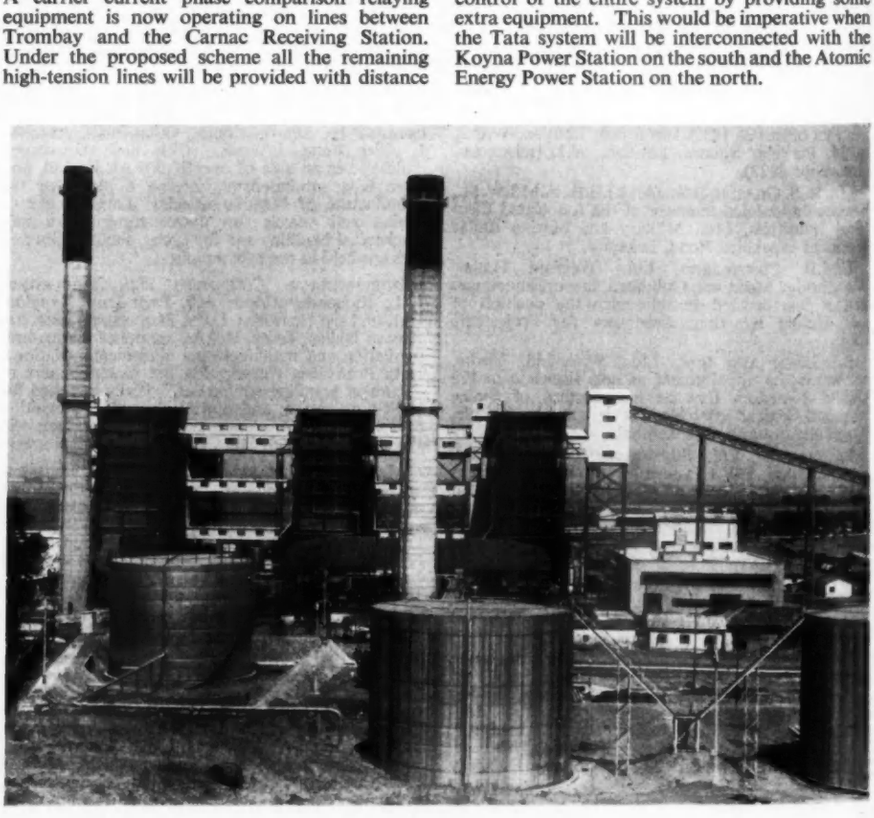
The high-voltage power lines, which so far were only used to carry electric power, will also be utilised to transmit a number of other quantities and signals to render the following services : (i) Voice communication (telephony) ; (ii) Carrier relaying for high-speed protection of power lines ; (iii) Telemetering of important quantities from the generating and receiving stations to the load dispatch control room at Trombay ; (iv) Teleprinter service for important messages and operating data and (v) Remote control of circuit breakers and provision for future load/frequency control of the system.

In order to ensure a reliable supply of power steps have already been taken to equip all the 110kV lines with the latest relaying equipment. A carrier current phase comparison relaying equipment is now operating on lines between Trombay and the Carnac Receiving Station. Under the proposed scheme all the remaining high-tension lines will be provided with distance relays which will be carrier current operated. In case of a fault on any line relays protecting it will detect the fault and send tripping commands to the breakers on either side of the line and hence will isolate the fault from the rest of the system within a fraction of a second. The voice frequency couplers which will inter-connect the distance relays with the high-frequency carrier current sets will be completely transistorised and will work on the latest practice of carrier current protection, i.e. on "frequency shift" principles.

In the first stage of the programme there will be facilities for telemetering all the quantities like the active and reactive powers generated at the generating stations to the load dispatch control room at Trombay so that the load dispatcher has a complete picture of the generating position of each of the plants. In addition it is proposed to telemeter the forebay level of Khopoli Power Station to make the maximum use of the water available in the lakes and avoid any of its loss. The high-voltage reading of the Poona Receiving Station will also be telemetered to Trombay to keep the load dispatcher constantly informed about the supply voltage to this station. In the second stage of the telemetering programme it is envisaged to bring more quantities and indications which would be necessary to facilitate load frequency control from the load dispatching station.

Page type teleprinters will be installed at all the generating and receiving stations, load dispatch control room and also at the head office. Important operating messages and data will be transmitted and received through the teleprinter service. This will facilitate transmitting of required information on paper and ensure a correct understanding of the various instructions issued.

At present the circuit breakers controlling the Trombay-Carnac Receiving Station lines at Trombay are connected with Carrier Current Transferred Trip Equipment, so that they could be remotely operated from the Carnac Receiving Station in case of an emergency. It is proposed to adopt the same arrangement on all the future lines terminating at the Carnac Receiving Station. Regarding the remote control of the generating stations from the load dispatch control room at Trombay, sufficient provisions have been made in the present carrier current scheme so that at a later date it would be possible to go one step ahead in the field of "Carrier Current Remote Control," and switch over to load frequency control of the entire system by providing some extra equipment. This would be imperative when the Tata system will be interconnected with the Koyna Power Station on the south and the Atomic Energy Power Station on the north.



Trombay thermal power station

CONTINENTAL AFFAIRS

by Our Continental Editor

German Industries Fair at Hanover

No. III—(*Continued from page* 838, *May* 19, 1961)

KRET

THE "Kret" ground piercing equipment invented by the Polish designer Wiktor Zinkiewicz and exported by Metalexport, Warsaw, P.O. Box 442, was demonstrated on behalf of the German licensee, Demag Aktiengesellschaft, Duisburg.

The device is a pneumatically operated motor which is driven by blows from an internal piston ram against an anvil in the nose, at the rate of about 470 blows per minute. It can be used to drive horizontal or sloping straight holes for pipes or cables. The diameter of the tunnel produced is approximately 90mm and a length of 30m is considered normal. The mole compresses the ground laterally and does not throw any material to the rear. Owing to its long length compared to its diameter, it will accurately maintain its direction provided it is not too near the surface. A minimum depth of 1m to 1·5m is suggested. If a shallow hole is unavoidable, a length of pipe may be trailed to help maintain a straight line.

To start the hole, the device is placed on the side of an embankment against the wall of a pit in a setting stand or, for greater accuracy, an aiming gear. Where little precision is called for, aiming may be performed using a simple trestle.

The implement trails its own compressed air hose as well as pipes or a steel cable for pulling in electric cables. A starting valve is incorporated in the air hose a short way behind the mole. This allows the device to be stopped, e.g. for the purpose of attaching further pipe lengths, and to be restarted.

It is claimed the device is specially useful where cables or pipes are to be laid under streets, railway tracks, runways, or buildings, as this can be done without disturbing the surface. Other applications in geological research, salvage of wrecks, and mine rescue, are being investigated.

At a working pressure of 6 atmospheres and with an air consumption of about 2 cubic metres per minute, the device pierces the ground at a rate varying from about 30m per hour in sand and 42m per hour in clay down to 2m to 6m per hour in compact gravel.

The mole has a length of 1300mm and a diameter of 88mm. Its shape is that of a very elongated artillery shell or steel gramophone needle, and it weighs 29 kg. For producing a hole up to 150mm in diameter a divergent conical tailpiece may be attached. Special connectors can be used to let the "Kret" trail pipes of 2in or 4in diameter.

THYSSEN INDUSTRIE

Thyssen Industrie G.m.b.H., the youngest subsidiary of August-Thyssen Hütte A.G., Duisburg-Hamborn, showed a cross-section of its production programme which includes the manufacture of galvanised sheet steel and also mechanical engineering products, including hydraulic roof supports for mines and track brakes for railway shunting yards. In Fig. 13 we illustrate an interesting application of galvanised sheet to floor construction in multi-storey buildings. Developed in the U.S.A., the method has been used in the new Thyssen head offices. Trough-shaped or double trough-shaped corrugated sheets are tack welded to steel joists or fixed with bolt-setting guns to concrete beams. Metallic ducts for services are fitted to the top and embedded in the floor concrete which is load-supporting immediately on setting. A sound-insulating false ceiling is slung under the floor.

SKIL

An electro-pneumatic hammer or chisel made by Skil (Nederland) N.V., Breda, was shown by the European distributors, Elmag Maschinen G.m.b.H., Frankfurt/Main, Kirchnerstrasse 6/8. The tool is made in two sizes weighing respectively 5·9 kg and 11·2 kg and powered by a 700W or 900W motor. The motor drives a reciprocating compressor piston which in turn carries a piston free to move in the barrel of the pneumatic hammer. By employing tools with a long hexagon shank, a round shank, or a short hexagon it is possible to obtain a combined hammering and rotary action (as for drilling concrete), a hammer action without rotation, and a pure rotation (as for drilling steel). The larger of the two machines can drill up to 2in diameter in concrete and 18mm in steel. In connection with this equipment there was demonstrated a self-cutting expansion dowel made by Société SPIT.

SOCIÉTÉ SPIT

The "Roc" threaded dowel made by Société SPIT, Route de Lyon, Bourg-les-Valence (Drome) is set in concrete with a cement ratio of up to 600 kg per cubic metre. Made in three sizes (8mm, 10mm and 12mm diameter) it is provided with a hardened end like a rock drill which allows it to pierce its own hole. It may be driven by means of an electric or pneumatic power drill or by hand. The hole is of accurate calibre, debris and dust being removed through the hollow centre during the driving. After piercing the hole to full depth, the dowel is withdrawn and its head is fitted with an expander cone which when forced against the bottom of the hole spreads the slotted body of the dowel. Contact between the dowel and the tool is by way of an adaptor cone which is subsequently broken off. Full load can be applied immediately. The dowel is stated to resist withdrawal with a force of 3 to 10 tonnes.

DEMAG-ZUG

A suspension stacker crane which makes it possible to stack and withdraw pallets fully automatically by dialling on a control desk, was shown by Demag-Zug G.m.b.H., Wetter (Ruhr). Our illustration (Fig. 14) shows the crane in the demonstration storage bay. By means of such a crane it is possible to stack as high as 10m, or in special cases even higher. Space required in the alleys and headroom is stated to be very moderate.

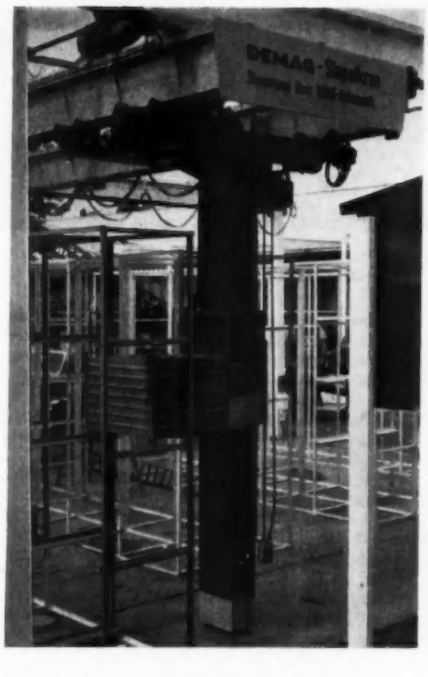


Fig. 14—Automatically-controlled stacker crane—Demag-Zug

Each compartment in the store bears a three-figure number. The crane automatically travels to the dialled distribution, positions or withdraws a bin, and returns to its point of departure, e.g. the despatch bay.

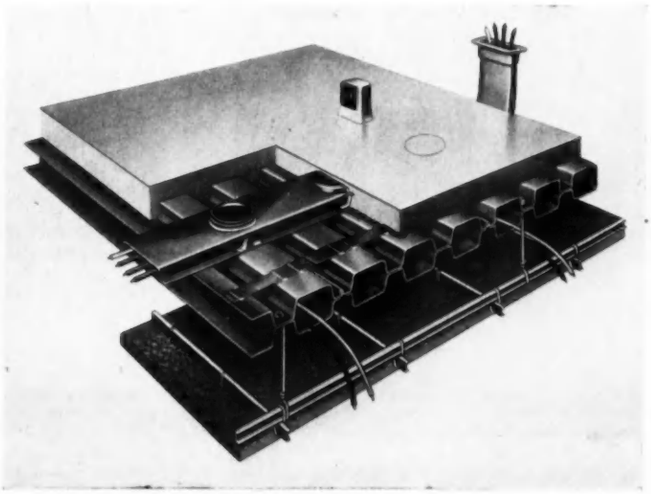


Fig. 13—Construction of concrete floor using galvanised steel sheet as permanent shuttering and tension element. The corrugated sheet is formed into box sections by spot welding and crimped joints. Services may be run inside the sections from which the ceiling of the lower storey is suspended — Thyssen Industrie

CONTINENTAL AFFAIRS *(Continued)*

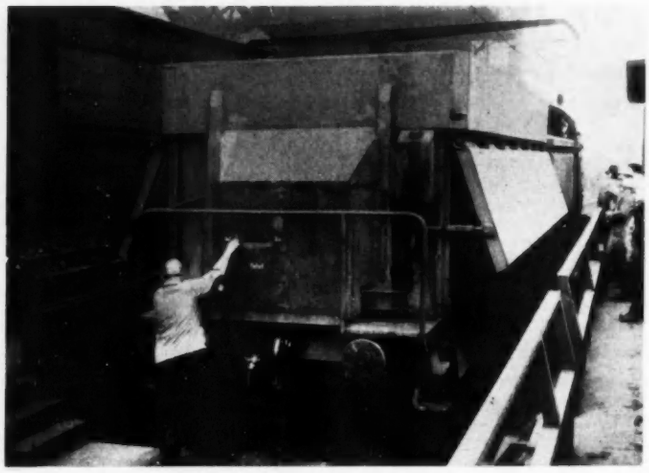


Fig. 15 — Hydraulically-operated side-discharge wagon — Orenstein-Koppel und Lubecker Maschinenbau

Orenstein-Koppel und Lubecker Maschinenbau

In the foreground among this year's exhibits by Orenstein-Koppel und Lübecker Maschinenbau Aktiengesellschaft, Dortmund and Lübeck, were diesel locomotives and railway rolling stock. These were exemplified by 50 h.p. and 140 h.p. shunting engines, both equipped with hydraulic transmission and capable of starting efforts of 2·9 and 7·25 tonnes respectively.

In Fig. 15 we show the company's side-discharging truck in operation. This design has a flat bottom which is hinged along the centre line. By hydraulically opening the flaps along the sides, and raising the centre of the bottom, the wagon is discharged in an effective manner even with sticky or frozen material. The absence of a saddle makes it possible to use the available space to the fullest extent, while the flat bottom permits the carrying of heavy piece goods. The 42 cubic metre wagon weighs 24 tonnes, and can carry 80 tonnes.

Dr. Lehfeldt & Co.

An ultrasonic washing plant shown by Dr. Lehfeldt & Co. G.m.b.H., Heppenheim (Bergstrasse) permits the carrying out of three washing stages in a single chamber, with considerable saving of space. For large and bulky components the firm has put on the market vibration troughs with impulse drive. Improvements to its ultrasonic welding machine, first shown last year at the Hanover Machine Tool Exhibition, include automatic electric controls, a timer which makes it possible to set and accurately maintain optimum welding times, and a built-in coolant tank with pump which obviates the need for a supply of cooling water. The machine can weld two thin foils, a thin foil to a thick sheet, spot-weld a copper wire on to aluminium, &c. The ultrasonic horizontal drilling machine "Diatron" (Fig. 16) works fully automatically. The machine is intended to drill or cut glass, ceramics, semiconductors, tungsten carbide, and in general any kind of brittle or hard material. For instance, it is possible to cut twenty or more glass blanks for lenses one after the other, with automatic actuation of the drill and feed of the glass plate.

Rubner

Fahrzeug-und Gerätewerk Rubner, Mellrichstadt, Bavaria, has introduced a pot-mounted roller with which roller conveyors can be constructed by inserting the components in a suitable support table. By orienting the rollers so as to be always tangential to the required path, curves and sections can easily be built. The pot design facilitates setting-up the roller in the right direction. Other applications include the transport of press tools, and of material on various kinds of machine tool. The rollers are made in two versions with carrying capacities of 20 kg and 50 kg.

Sauter

A machine for forming scarfed joints in timber has been developed by Rudolf Sauter Maschinen- und Apparatebau, Erlenbach-Mühlacker (Württ.). This has a traversing table to which are clamped two or more pieces which are to be jointed. They are first trimmed square by a circular saw, and in the same operation tenoned by a multiple vertical cutter. The profile of the tenons has one flank parallel to the long dimension of the timber, and the other flank partly parallel and partly sloping, forming a wedge. With the mating piece turned through 180 deg. the joint can be assembled with two series of parallel flanks forced into contact by the wedge action of the sloping flanks. This, it is claimed, forms a joint equal in strength to the timber itself. It is not necessary to wait for the glue to set and further operations can take place at once.

Kampnagel

At the stand of Kampnagel Aktiengesellschaft (Vormals Nagel & Kaemp), Hamburg 39, Jarrestrasse 26, was to be seen a 20-ton semi-portal bloom handling crane, designed specifically for the handling and turning over of blooms for flame-scarfing. As Fig. 17 shows, the crane bridge is of welded construction. Of the four support wheels, one on each track is driven by a separate geared motor unit. The crab structure is also welded and consists of the crab frame, the square section girder shaft with the magnet cross piece and the guide tube. The crosspiece is suspended on two doubled ropes and can be raised and lowered by a two-drum hoist. The guide tube is supported on trunnions which allow deflection in the direction of travel of the crab during the turning procedure. This movement is strongly damped by a toggle mechanism fitted with an adjustable spring.

The hoist and travelling drives are powered by asynchronous slipring motors precisely controlled by brake generators. Current reaches the crab through flexible cables suspended from roller brackets carried on a support structure.

Brown Boveri & Cie

Currents up to 130A (at 300V peak voltage) can be controlled by a silicon thyratron exhibited by Brown Boveri & Cie. A.G., Mannheim. Such elements have an efficiency of 98·5 per cent, and find application to speed controls in sizes up to 100kW, in particular in vehicles, cranes, and ships because they are insensitive to shocks and accelerations. A smaller silicon thyratron, for 15A mean current and 350V peak voltage, was shown applied to an equipment for controlling the intensity of stage or studio lighting. The air-cooled 10kW unit measures only 400mm by 270mm by 180mm and is designed for rack mounting.

A single anode mutator, for 100A mean d.c. current and 3000V peak voltage, has been designed with particular attention to the saving of space and to exchangeability. The mutator tank and all ancillary components can be taken out of the housing and replaced as a unit.

For minor replacements and repairs the unit needs only to be pulled a little in order to disconnect the plug-in terminals. A faulty mutator in a group can easily be traced with the help of an indicator lamp which lights up. The method of construction also reduces the number of spares that have to be carried, a single replacement unit being in general sufficient.

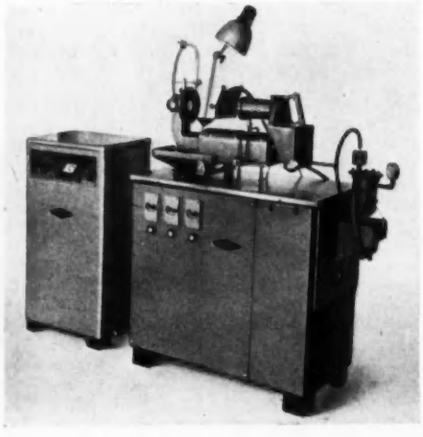


Fig. 16—Ultrasonic drilling machine with automatic control—Dr. Lehfeldt and Co.

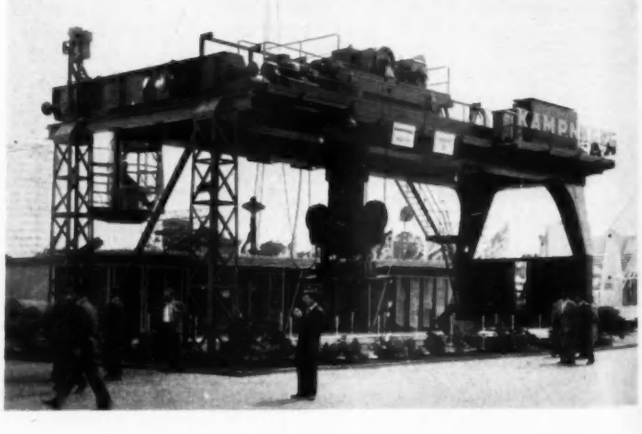


Fig. 17—Semi-portal bloom handling crane—Kampnagel

Ernst Leitz

Applications of the "Leica" camera to technical and scientific research, projectors, microscopes, and various physical-optical instruments were shown by Ernst Leitz G.m.b.H., Wetzlar. We confine ourselves to describing a light section microscope attachment, and the "MP5" scale reading projector. The light

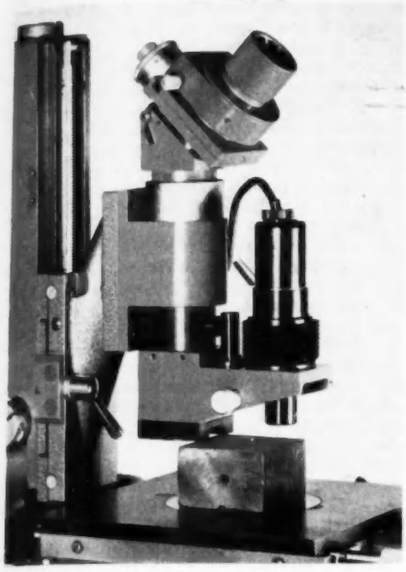


Fig. 18—Measuring microscope with light section attachment—Ernst Leitz

section attachment (Fig. 18), is used in conjunction with the company's toolmaker's microscopes. A narrow pencil of light is thrown on to the surface under test which it intersects at an angle of 90 deg. The method is stated to be suitable for macro-geometric investigations and control of the surface shape of cutting edges, files, profile rolls, engraved shapes, and especially thread rolls. Graduated eye-pieces permit cutting or flank angles to be measured to the nearest twenty minutes of arc or better, or the measurement of short lengths.

The scale projector is intended for reading metal scales of machine tools provided with millimetre or 0·05in divisions. It works with direct illumination and projects single divisions on to a ground glass screen. A micrometer head with zero setting permits the projector to be set and read directly to 0·005mm (0·00025in). It is possible to rotate the instrument about the axis of the projected light ray without affecting the movement of the image, so that the instrument can always be mounted in the way that is most convenient for taking readings. The scale is mounted with its surface vertical so as to reduce the chances of damage or accumulation of dirt.

Malcus

A high-speed steel drill made by Malcus, Halmstad, Sweden, was demonstrated by the German distributor, Fritz Wegener, Hamburg 22, Osterbekstrasse 43. The flutes of these spiral drills are produced by rolling. The hard oxide skin absorbs some of the cutting fluid, as a result of which, it is stated, the drills last many times longer than bright drills in materials forming long chips. Particularly astonishing was the resistance to fracture. The demonstrator drilled an $\frac{1}{8}$in diameter hole through $\frac{1}{4}$in mild steel plate, and then by tilting the plate bent the revolving drill through an angle of approximately 20 deg. until it cut its way out at the edge of the plate, returning to a straight shape.

Dingler

Dinglerwerke Aktiengesellschaft, Zweibrücken, showed examples from its production of mine ventilators. In mine ventilating installations it is necessary to provide for the rapid replacement of the working parts of the fan. Regulations require the mine to be cleared if fans are out of action for more than twenty minutes. Therefore if it is not possible to effect the change-over in that time a complete standby ventilator has to be available. In the case of a vertical 5000 to 9500 cubic metres per minute ventilator, the rotor bearings are supported in one-half of the split stator. After uncoupling the drive, this section together with the rotor can be withdrawn sideways on a trolley and a spare can be inserted. The motor is housed above the fan in the central portion of the diffusor annulus and can easily be removed and replaced by means of a travelling crane. The motor receives cooling air through the hollow diffuser supports.

Another installation shown in model form comprised two horizontal fans each of 2500 to 10,000 cubic metres per minute capacity, arranged in parallel. This constitutes the first stage of complete ventilating plant and was completed last year. Each fan has a two-stage axial flow rotor with hydraulic variation of the blade pitch: it is this which makes possible the wide operating range. A further similar fan is to be added later, giving a total capacity of 7500 to 30,000 cubic metres per minute against a pressure difference of 180mm to 460mm H_2O. An automatic control ensures that all three fans can operate nearly to the breakaway limit without surging. With such a range it is possible to carry out overhauls on one set while maintaining operations with the help of the other two. All three rotor sets are supported on saddles in split stator housings and in this way can easily be exchanged. They are interchangeable with one another or with any similar fans of the same design at another mine belonging to the same company.

Stromag

A cable carrier "Kabelkuli" made by Stromag, Unna (Westphalia).—U.K. representative: J. H. Obermann & Sons, Ltd., 16, High Street, Higham Ferrers—permits the crab of a travelling crane to be connected by flexible cables. The carrier is a flat steel frame which runs on rollers on the crane rail. At each end there is a series of rollers set in a semi-circle and a further number of roller supports are arranged along the top. The cable or cables are carried in a complete loop over these rollers, the lower horizontal section hanging freely. Connections are made at a point at the top, and at symmetrically placed points near the other end and at the bottom of the cable loop. One of the points is connected to the mains, the other to the crab. Displacement of the carrier amounts to half the movement made by the crab.

A miniature two-pole or four-pole contact rail conduit measures in section only 90mm by 145mm, including the fixing channel. The contactor runs on rollers in the conduit, the overall height of channel plus contactor being only 225mm. There is provision for cable openings on all four sides of the terminal box and at the bottom, and for a carrier to extend laterally on either side or downwards.

Trennjager

A pneumatic attachment for three of its high-speed metal cutting machines has been introduced by Trennjäger Maschinenfabrik, Euskirchen/Rhld. This allows the machines in question to be converted to semi-automatic production.

The largest of the three models is equipped with a 3000 r.p.m. three-phase motor of 6 to 10 h.p. which directly drives a toothed steel cutter blade of 520mm diameter and 3mm thickness. Sections up to 320mm width and 670mm along the longest diagonal can be cut. As examples of the extremely high cutting speeds, the firm quotes one second for a 50mm by 50mm by 5mm angle, or two seconds for cutting off a pipe of 100mm diameter and 3mm wall thickness. About 3000 cuts may be taken before the saw blade needs to be resharpened. For cutting it is not necessary to clamp the material.

The pneumatic attachment feeds the movable headstockto ward the workpiece, which the operator rests against a stop bar on the machine table. This allows the operator the use of both hands and reduces fatigue. On completion of the cut the work head returns automatically to the starting position, but the return can be operated by a footswitch at any point of the cycle when necessary. Cutting to length of bar stock and sections is facilitated by a roller table and adjustable end stop.

Norddeutsche Maschinen-und Schraubenwerke

A universal tower jib crane with a maximum height under the hook of 87m was exhibited by Norddeutsche Maschinen-und Schraubenwerke A.G., Peine. The crane (Fig. 19), a "Model 40/50/63" has a capacity of 6·3 tonnes at 8m radius (maximum hook height 73m) and 1·25 tonnes at 32m radius (65m under the hook).

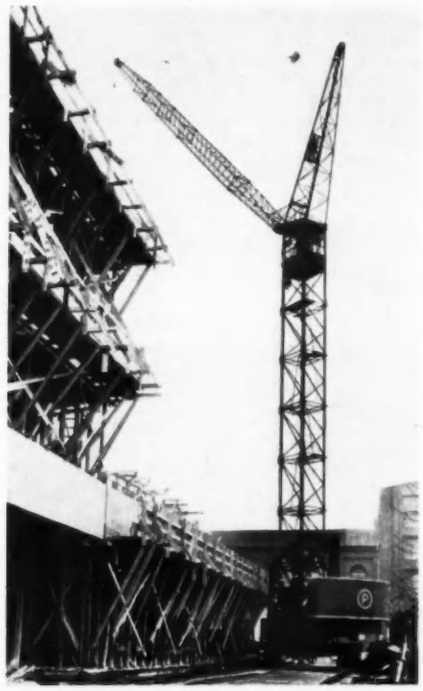


Fig. 19—Jib tower crane—Norddeutsche Maschinen- und Schraubenwerke

The head pulleys can be attached to the jib in five positions, giving different radius/load characteristics. With the load carried at the jib head at the minimum radius of 12·5m—when the maximum height under the hook is 87m as mentioned above—the crane can lift 2·5 tonnes. With such a tower the crane weighs 63 tonnes, exclusive of 22 tonnes ballast.

In spite of its large size, the crane can be towed on the road by a tractor in a simple manner. For this purpose, the cross-shaped underframe has two opposing stabiliser beams hinged at the centre so that they can be brought into line with the other two, which are rigid, by turning them through right angles. The underframe is then jacked up on pneumatically-tyred bogies, an operation taking only a few minutes.

The upper end of the tower, including the driving cabin with connections for the jib feet and "A" frame, remains in position on the slewing hoist platform. In the transporting position the width is 3m.

Both jib and "A" frame are bolted in while the tower is still on the ground. The tower is erected by adding 2·5m-high sections one at a time at the lower end. To this end, the tower as a whole is lifted by the height of one section by means of a parallelogram linkage actuated by hydraulic jacks. An additional section is then raised on to the platform by a small auxiliary hoist, and inserted. Dismantling is done by going through the same procedure in reverse (Fig. 20). The superstructure is counter-balanced by a steel tank holding 22 tonnes of gravel ballast.

The underframe is designed to travel on four two-wheel bogies on a rail track of 5m gauge

CONTINENTAL AFFAIRS *(Continued)*

with minimum inside radius of curvature of about 6·3m. The track gauge can vary slightly. Automatic travelling brakes are fitted. Gearboxes for hoisting and derricking are supported free from torsional forces. Brakes on the hoist and derrick winches are hydraulically lifted, and the slewing brake is hydraulically operated. Two-lever operation is provided from the upper or lower control position, with the possibility of

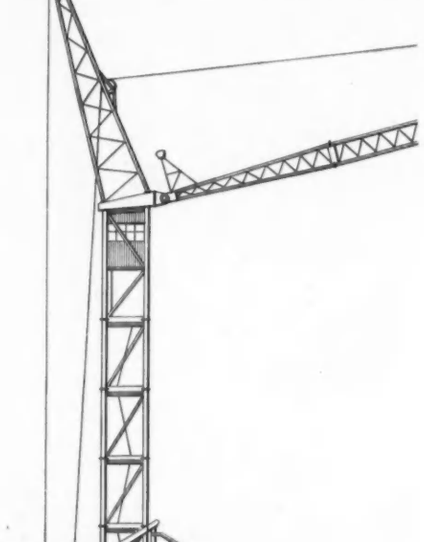


Fig. 20—Method of erecting tower—Norddeutsche Maschinen-und Schraubenwerke

remote control by means of cables or radio. Special means of protection are provided against slackness in the rope, simultaneously limiting the lowest position of the hook. The crane is also safeguarded against failure of one of the phases in the electric supply, and against overload applied through either the hoist or derrick winch. As alternatives, the hoist can be equipped with d.c. resistance braking, pole-changing slip-ring rotor control for quick hoisting and lowering of light loads, frequency-changer control for 8 per cent. inching speeds up or down independent of load, or Ward-Leonard control giving accurate stepless speed variation independently of the load with automatic speed increase with light loads. A 63 h.p. hoist motor gives speeds of up to 100m per minute with a 2·5-tonne load on a single rope, and 50m or 25m per minute with 4-tonne loads. With Ward-Leonard control the speed ranges are 1·25m to 25m per minute, 2·5m to 50m per minute, and 5m to 100m per minute. A 40 h.p. motor derricks the jib from 15 deg. to 70 deg. in about fifty seconds, while an 8 h.p. slewing motor can rotate the crane at a speed of 0·8 r.p.m. The slewing run is fitted with "Rothe Erde" wire track ball bearings. Maximum travelling speed is 60m per minute, with two drive motors of 16 h.p. each.

Stohr

A suspended totally enclosed tube conveyor was shown by Wilhelm Stöhr, Offenbach/Main. The design, due to Schaeffer, comprises an endless rubber belt suspended from a metallic roller track. The rubber belt is folded into a pouch and sealed by a double zipp-fastener moulded in rubber (Fig. 21). Before closure of the fastener takes place, the material is inserted from the side by means of a hopper. The conveyor discharges by opening the zip-fastener which is protected by a flap against coming into contact with the contents. American experience with similar zip-fasteners is stated to have shown that they are hard-wearing, easy to operate, insensitive to dirt, and largely self-cleaning.

The conveyor demonstrated at the German Industries Fair had a speed of 0·5m per second and could support 50 kg per metre. With an effective cross-section of about 0·05 square metres it

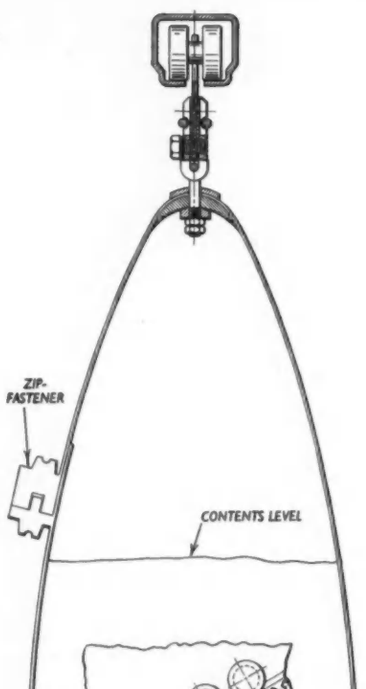


Fig. 21—Pouch conveyor with closure by zip-fastener—Stohr

had a capacity of 100 cubic metres per hour (150 to 200 tonnes per hour), but larger sizes are stated to be feasible.

The conveyor is supported on rollers between which the tractive effort is transmitted by a chain so that the belt itself is subjected only to the load of the material. Owing to this fact the belt material requires only light or no reinforcement. The rollers run in the channel track of a standard suspension conveyor, but suspension from a wire cable is stated to be also feasible.

The design is stated to be suitable for small radii and steep rises. Depending to some extent upon the nature of the conveyed material, gradients of the order of 50 deg. can be negotiated. The contents are completely protected from the weather, and in turn cannot contaminate the surroundings.

Muhlhauser

For underground use in mines, the firm Karl-H. Mühlhäuser, Michelstadt/ODW, produces a 3·25 cubic metre concrete re-mixer. The machine consists of a drum of 1350mm o.d. resting on a three-point support and driven at 50 r.p.m. by a geared 12·5 to 20 h.p. pneumatic motor. Mounted on two bogies for wheelsets of 600mm to 914mm gauge, the mixer has an overall length of approximately 3900mm, a height of 1850mm, and a width of 1500mm. It weighs 4800 kg. In transit the drum is closed by a screw-down cover. The front part of the discharge shute can be tilted upwards.

AB El- & Gassvetsning

A non-return valve to prevent blow-back of explosive mixtures in oxy-acetylene welding has been put on the market by AB El- & Gassvetsning, Gothenburg, Sweden. The design, the Elga "Triplex," fulfils three functions. A porous barrier constructed of sintered stainless steel stops the explosion pressure wave. Then a conical valve actuated by a membrane shuts off the line. At the same time, the line is also closed to gas flowing in the normal direction by means of a second valve. This prevents the further escape of the explosive mixture and thereby reduces the danger of fires. This second valve requires resetting by means of a screwdriver before the line can be put into use again.

Dansk Svjesemaskine Fabrik

A twelve-station spot-welder for coil windings and switch contacts has been put on the market by Dansk Svejsemaskine Fabrik Hans H. Larsen & Son, Copenhagen N, Borups Allé 128. The machine is equipped with a pneumatically operated rotary worktable. In each welding position, three spot welds are carried out in rapid succession. The fully electronic control allows the workpiece to be preheated (for removing insulation) as well as the carrying out of a multi-impulse weld with a preselected number of current pulses and intervals. The speed of the machine is adjusted to enable the operator to work steadily inserting and removing workpieces, unless these operations are also mechanised.

Morganite Exports

Electric heating elements in the form of spiral rods of silicon carbide suitable for temperatures up to 1575 deg. Cent. were shown by Morganite Exports, Ltd., Battersea Church Road, London, S.W.11, a member of The Morgan Crucible Group. These "Crusilite" elements are stated to exhibit a particularly slow increase in resistance with age, so that a 40 per cent voltage reserve is adequate for full operation throughout the whole of the working life. Operation is by means of transformers or directly from the mains. The rods are insensitive to being switched off, so that shutdown at night or over week-ends does not reduce their life. It is possible to replace a faulty element without having to wait for the furnace to cool down. It is also claimed that "Crusilite" rods will stand up to a wide range of atmospheres. A novel design of heater rod has both terminals at the same end. This kind of rod can be inserted into the furnace from either top or bottom, or from the side.

Autogenwerk Zinser

For buttwelding polyvinyl chloride floor coverings, Autogenwerk Zinser, Ebersbachfils, has put on the market a machine giving a feed of 0·5m to 3·5m per minute and generating the necessary compressed air for an electrically heated hot-air welding torch. A reel for the weld material is mounted between the torch and the compressor. The automatic welder is built for connection to 220V or 110V a.c. mains and has a maximum consumption of 650W.

Association Technique Maritime et Aeronautique

THE Association Technique Maritime et Aeronautique held its annual meeting on May 15, 16, 17 and 18 at the Maison de la Chimie, 28 bis, rue Saint-Dominique, Paris. Following the general meeting A. Andige gave his paper "The International Conference for the Safety of Life at Sea—London, 1960," which underlined the changes and additions to the existing regulations and explained the new rules concerning the carriage of grain and nuclear propulsion. In his paper, "Spare Parts in Air Transportation," R. Josse gave an evaluation, based on experience, of the spares necessary to insure normal operation of an aircraft throughout its life. The first paper on Tuesday morning was by M. Jourdain and entitled "Contribution to the Study of Ship Model Correlation," and maintained that ship-model correlation may be empirically determined by a set of coefficients which will take into account, speed, power, revolutions, thrust, &c. G. Solda in his paper gave an approximate formula for the calculation of the cross section of the automatic trimming ducts, required by the International Convention of London, 1960, to deal with unsymmetrical flooding. This was followed by the "Estimation of the Shaft Horsepower for a Single-Screw Ship," by S. Bindel and M. Gargnet, which proposed a method to estimate quickly the shaft horsepower of a single-screw ship when the block and prismatic coefficients are known. The data obtained from the analysis of resistance and propulsion of a large number of tank-tested models was given graphically. H. Werte gave the fourth paper of the morning, "Physical Study in the O.N.E.R.A. Water Tunnel of Phenomena Related to Vortices," and this stated that from the tests the conical structure of the flow becomes apparent as well as the characteristics of the vortices, their location, the evolution of their axial velocity, and the helical shape of their core streamlines.

The afternoon session opened with "Industrial Applications of Infra-red Radiation to Surface Temperature Measurement" by J. Crabol. One apparatus measures the temperature of turbine blades in a turbo-jet during flight and a second equipment allows the study of temperature gradient along a model subjected to heating. The paper "Contribution to the Studies of Supersonic Jet Deflection" by G. Ernst and F. Tremouilles referred to the control torques for rocket missiles by jet deflection and summed up the studies at S.N.E.C.M.A. which led to the development of a directional nozzle with adjustable pressure chambers. J. Fruckus in his paper "In-flight Measurement of Combustion Efficiency" discussed the analysis methods for combustion gases during flight and gave a general survey of the present status of the technique and the main characteristics of the elements used for gas sampling and analysing in flight. "About the S.T.O.L. Aircraft" by P. de Valroger suggested that the best answer to the S.T.O.L. problems was to equip a standard plane with two "Turbobarillets." The last paper read on Tuesday was "Experimental Study of the Velocity Stabilisation of an Airplane for Control during Approach" by J. Alliet.

"Research in Material Used for Manufacture of Air-Heater Tubes of Boilers" by M. Granier was the first paper presented on Wednesday morning and summed up the results of laboratory tests on, and examinations of, different materials to be used for air-heater tubes. Two forms of corrosion were studied and the paper ranks the materials according to their resistance to both forms of corrosive attack. G. E. Merlin and J. Bouvier in their paper "Considerations in the Use of Medium Heavy Fuels of Various Viscosities for Ship Propulsion" described the equipment installed in five old ships for conversion to burn medium heavy fuels and gave a financial balance sheet. This indicated that there was no further financial gain, under present conditions, in using fuels of higher viscosity than 800 seconds Redwood. J. Gaborit, J. Porcher and R. Uguen gave the next paper "Experimental Investigation of the Problems Raised by the Process of Expanding Exchanger Tube for Heavy Water Loops for El.3," which was concerned with the manufacture of low carbon 18/8 stainless steel heat-exchanger tubes. The last paper of the morning session was "Elements of Dynamics Concerning Boilers" by C. Macherey, and was a study of boiler-tube systems and the effect of the water downcomer in the dynamical balance in the separating tank, and also of the heating inertia of the metallic parts of a superheater.

The title of the first paper given on Wednesday afternoon was "Hatchway Design for Cargo Ships: An Improvement for Cargo Handling," by P. L. Bain and R. Jacquinet, and discussed the improvements in the design of steel hatch covers which permitted the extension of hatchways to reduce the amount of horizontal handling of cargo. In the next paper "Stainless Steel for Ship Propellers," by J. Hochmann, the properties of stainless steels suitable for manufacturing ship propellers were reviewed and a 16 per cent chromium martensitic steel alloyed with nickel and copper was stated to have high mechanical properties. However, duplex-structure steels containing austenite and ferrite, although having lower mechanical properties, are more corrosion resistant and have good welding properties. M. Jourdain in his paper "First Results of the Statistical Study of Stresses at Sea on Merchant Ships" gave the results of measuring the strains suffered by merchant ships at sea and compared them with other results published elsewhere. The main role of generators, and an examination of the division of costs as between fuel, maintenance, &c., was the subject of the paper "Remarks Concerning the Production of Electricity on Board Ship by Diesel and Turbo-Generators," presented by G. E. Merlin and J. Bouviér. The afternoon concluded with the reading of "Corrosion of Propeller Shafts" by A. J. Maurin.

The meeting continued on the morning of Thursday, May 18, with a paper by J. Lachassagne entitled "Complement about the Whirling Vibration of Rotating Shafts," and was complementary to an earlier theoretical study of the subject. The method for calculation of the first resonance was described and a simple experimental means to check the calculation suggested. In their paper "Sea Trials in View of Improving the Behaviour of Propeller Shafts and Their Bearings," G. Bourceau and A. Loupéré gave an analysis of the results of propeller shaft vibration readings which indicated that the behaviour of shafts and bearings could be improved by propeller design, alignment of parts and positioning of the bearings. "Proceeding to Study the Free Torsional Vibrations of Reciprocating Engine Crankshafts, to be Applied to Digital Computers" by C. Caputo, was the title of the next paper, and was followed by "Distribution of Loads on Sterntube Bushings on Large Oil Tankers" by J. Legris. The afternoon opened with the reading of "Contribution to Non-Destructive testing by Macrography and Micrography" by G. Dague and the next paper "Inconsiderate Use of Welding ing for Parts Under Cyclic Stress," by H. de Leiris, described some examples of improper application of welding in ships. E. Mencarelli gave the next paper "Extension of Microfractographic Analysis to Fractures of Parts," and examples indicated the ability of electronic microfractography to identify failure processes and to determine the direction of fracture propagation. The concluding paper of the meeting was "The Drop-Weight Test (Pellini Test) and the Welded Joint," by H. de Leiris and R. Bonizec, in which examples of the application of the drop-weight test to iron sheets were given and its extension to butt welded and cruciform welded joints. The proceedings of the sixty-first meeting of the Association closed with a visit to the Laboratoire National d'Hydraulique, quai Watier a Chateu, on the morning of Friday, May 19.

Enlarged Economy Car

There was announced last month the Citroen "AMI 6," a four-seater car designed to give economical motoring with great comfort. The mechanical conception of the car is similar to that of the well-established 2 C.V. model, with the wheels on each side connected by a single spring of an extraordinarily low rate, while the seats, which are readily removable, are deep and of the same softness as those of the DS-19. The horizontally opposed, air-cooled, push-rod, twin-cylinder engine has a swept volume of 602 c.c. (74mm by 70mm) and develops 22 b.h.p. at 5000 r.p.m.; its peak torque corresponds to a brake mean effective pressure of 122 lb per square inch at 2800 r.p.m. The gearbox has four underdrive ratios, all with synchromesh, and carries the front brakes, which have radially finned drums. Double universal couplings at each end of each propeller shaft give constant velocity drive irrespective of suspension or steering deflections. Each wheel has both friction and inertia dampers; the tyres are Michelin "X" 125 x 380.

A distinctive feature of the car is that the Cibie headlamps are, even as the beam emitted, wider than they are high. Each lamp has not one but three reflectors; the configuration may be conceived by imagining a large paraboloid in which the upper and lower portions have been cut off, reduced in scale and, of course, moved

The "AMI 6" is mechanically similar to the Citroen 2 c.v., but the bonnet, wings, doors and roof are separable from the load-carrying chassis girder. The plastic fan is distinguishable behind the grille; within its centre there is access to the cranking dogs

CONTINENTAL AFFAIRS *(continued)*

closer to the focus. Thus the light emitted in the horizontal plane has the advantage of a larger reflector than could be accommodated if the lamps were paraboloidal. Each lamp is pivoted about its transverse axis to allow adjustment of the lamp with change of load. It is claimed that the dipped beam is twice as bright as the European standard.

The car is claimed to be cheap to maintain, there being only four grease points ; however, two of these are for the sliding splines of the drive shafts and rotate with the shafts. The fuel consumption is estimated at 45–50 m.p.g. and the top speed as 65 m.p.h., this being a continuous rating. With the driver and one passenger aboard, the brakes will afford 0·8 *g*.

E.C.S.C. in 1960

In its ninth Annual Report the High Authority of the European Coal and Steel Community sets forth the achievements and progress of the E.C.S.C. in 1960. The most spectacular aspects have been a boom in steel production and investment. Under the effect of measures taken by the High Authority and the national Governments the coal situation has improved, particularly in Belgium, where High Authority action has eased the effect of pit closures and short-time working. The High Authority stresses, however, that reorganisation must continue in face of the continued competition from oil and natural gas. The re-adaptation of miners, made possible by the E.C.S.C. Treaty, has played a major part in enabling the reorganisation of the coal industry to take place without industrial strife.

The steel industry has carried through an unprecedented expansion without major difficulties in prices, raw material supplies or deliveries. Working hours have been reduced, following substantial increases in real wages in earlier years. The co-operation of energy policies between the three Community executives has now started to bear fruit.

It is hard to imagine, the report states, that such substantial results would have been achieved in reasonable time without the existence of a body independent of the individual Governments and able to weigh up the different interests involved while at the same time basing its decisions on the general interest of the Community as a whole.

Without the financial independence which the High Authority enjoys, the various borrowing, lending and credit operations carried through could not have been undertaken on such a scale.

Energy Policy.—In 1960 total energy consumption rose by close on 7 per cent in comparison with the 3 per cent that had been forecast—mainly as a result of the rapid growth of industrial production, which rose by about 12 per cent over the 1959 level. Of this increase, however, almost 60 per cent was met by oil, and the share of coal in the total continued to shrink at an average rate of some 2 per cent per year, as it has been doing over the past ten years (Table I). It is expected that in 1961 coal consumption will again be slightly below the level for the preceding year, even given a moderate expansion in industrial activity.

In their efforts to deal with this situation, the report continues, most of the member Governments are seeking to reduce excessive competition which could result in costly changes not in line with the long-term trend.

A first set of proposals designed to achieve a co-ordination of policy was submitted by the Inter-Executive working group to the E.C.S.C. Council of Ministers in March, 1960. This suggested four major objectives :

The most economic possible flow of energy supplies.

A single market for energy throughout the Community.

Security of supplies no matter what the state of the market at any given moment.

A dependable minimum volume of supplies for the Community.

To attain these aims, the executives proposed a mechanism involving an overall guide price for all fuels, based on forecast trends in the energy sector and taking into account the possibility of giving a margin of preference to Community fuels, for economic, political or social reasons.

The Council of Ministers, which examined these proposals, termed them " reasonable and attractive," and asked for further details on the guide price mechanism. It added, however, that the use of a guide price would not remove the need for other forms of action to deal with immediate problems.

Early in 1961, the Inter-Executive working group therefore submitted to the Council of Ministers a " Programme for Urgent Action," which recommended :

An agreement on first steps to bring into line the six countries' commercial policy, their rules of competition governing energy, and fiscal and administrative measures capable of producing price distortions ;

A consultation agreement, which would engage Governments not to take new measures on energy policy without consulting the other member countries and the three executives in the Council of Ministers, and also to provide regular general consultations on energy policy ; and

An agreement on emergency measures, such as import quotas or levies or subsidies on Community coal to deal with any sudden break in the energy market.

The Council is now studying these proposals.

Reduction in Coal Production Capacity.—The general trends in the energy market clearly call for a sustained and rapid effort to adjust the Community's coal industry to the changing situation, the report says. In Belgium the current programme of closures aims at a reduction of 9·5 million tons capacity by 1963 : and in Germany eighteen pits—representing an annual capacity of 6·5 million tons—will have been closed by the end of the current year. In France work continues on the reorganisation of the Centre-Midi coalfield for which a five-year adjustment programme has been prepared.

In Belgium, in spite of the special action undertaken in 1960 under Article 37, there is still a serious gap between production and sales outlets. The High Authority therefore decided, after securing a firm undertaking from the Belgian Government that the closures scheduled for 1961 would be carried out, to continue to allow coal trade between Belgium and the rest of the Community to be regulated. Subsidies were authorised for 3·3 million tons of coal, but on a descending scale, and on condition that the schedule of closures and output quotas was observed.

Improvement in the state of the Community coal market in 1960 was shown by various indications. Total supply and demand were more or less in balance, production lost through short-time working fell to 5·8 million tons, from 13·3 million in 1959 ; imports fell from 19·2 to 17·8 million tons ; and average output rose substantially to 1961 kg per man-shift at the end of the year, against 1819 kg at the end of 1959. The number of underground workers fell by 54,700, of whom 28,700 left the industry in Germany and 12,900 in Belgium.

Steel Boom.—In the Community steel industry, by contrast, the spectacular boom continued. Production of crude steel in 1960 reached the all-time record of 72·8 million tons, and the market remained extremely steady except for a slight flagging in orders from third countries during the summer. Total demand was up by 5 per cent on 1959, at 52·8 million tons of rolled products, exclusive of special steels. Intra-Community orders were 11 per cent up on 1959, though those from third countries fell by 19 per cent. Deliveries totalled 52·8 million tons, and orders on hand at the end of the year represented work for approximately three months ahead.

The highest rate of increase in steel production was reached in Italy, i.e. 21·5 per cent up on the previous year : the Community average was an increase of 15·3 per cent. The share of the Community in world steel production now stands at 20·7 per cent.

Investments.—Even more than the production figures for steel, the trend of investment figures testifies to the healthy development of the E.C.S.C. industries since the start of the Common Market for coal and steel. In the eight years 1952–60, they spent just under 8500 million dollars on investments, with a sharp rise in 1960, particularly in steel and in the iron-ore mines, after a slackening in 1959.

The beginning of an investment boom in steel is shown more clearly by the statistics of investment projects declared to the High Authority in 1960. In that year they represented net capacity increases of 13·2 million tons for crude steel and 8·3 million tons for rolled products. Their total value reached 1802 million dollars, compared with 495 million in 1959 and 410 million in 1958.

In 1961, the High Authority plans to publish new general objectives to serve as a guide for future expansion and modernisation. The previous general objectives, which dated from 1957, are no longer adequate insofar as the hypotheses adopted for their calculation require modification in the light of actual achievement. The basic studies for the new objectives are already under way.

TABLE I.—*Consumption of Primary Energy in the Community*

	Percentages					Million tonnes hard coal equivalent		
	1950	1955	1959	1960	1961*	1950	1955	1959
Hard coal	71·7	62·8	54·1	52·4	50·0	210·3	253·7	235·5
Brown coal	8·4	7·9	7·6	7·1	6·9	24·5	31·7	33·1
Oil	12·8	20·7	27·8	29·5	32·0	37·6	83·5	121·0
Natural gas	0·3	1·4	2·4	2·8	2·9	1·0	5·5	10·6
Water power and terrestrial heat ...	6·8	7·2	8·1	8·2	8·2	19·9	29·2	34·9
Total	100·0	100·0	100·0	100·0	100·0	293·3	403·7	435·1

*Provisional figures

Liability for Nuclear Damage

The text of a draft convention on Minimum International Standards Regarding Civil Liability for Nuclear Hazards has been completed by an intergovernmental committee convened by the International Atomic Energy Agency (I.A.E.A.) which met in Vienna from May 3 to 13, 1961.

The convention deals with nuclear hazards arising from land-based nuclear installations and in connection with the transport of nuclear material and constitutes a " framework convention " by establishing uniform basic principles for dealing on an international scale with the legal problems involved. It takes into account the U.N.E.C. Convention on Third Party Liability in the Field of Nuclear Energy (July 29, 1960), the results of the discussions on the liability of operators of nuclear ships at the Diplomatic Conference on Maritime Law (Brussels, April 17 to 29, 1961), and the different legal traditions of the Agency's Member States.

The draft as well as a report by the committee will be submitted to the Director General of I.A.E.A. who will present it to the Board of Governors for appropriate action.

The committee had before it a draft version originally prepared by an I.A.E.A. panel of experts constituted in December, 1958, and the comments on it received from Member Governments.

THE AMERICAN SCENE

By Our American Editor

Yankee Atomic Power Station in Massachusetts

No. III—(*Continued from page* 842, *May* 19, 1961)

The Yankee nuclear power station of the Yankee Atomic Electric Company at Rowe, Massachusetts, commenced electric power generation on November 10, 1960, *and is scheduled to be in full commercial operation by July* 1. *The station will have an ultimate thermal output of* 485*MW and an ultimate net electrical capacity of* 136*MW. It was built by the Westinghouse Electric Corporation at a cost of about* 40,000,000 *dollars and employs the firm's pressurised light-water reactor. The reactor core comprises some* 25 *tons of* 3·4 *per cent enriched* UO_2 *pellets in stainless steel tubes. It is expected that the new station will eventually provide power at a cost of* 0·9 *cents per kilowatt-hour.*

Main Coolant System

The main coolant system is contained in four radial loops attached to the central reactor, each loop consisting of a single steam generator, canned motor circulating water pump and non-return valve. Each loop can be isolated for maintenance by a pair of motor-operated gate valves, which are provided with piped stem leak-offs to dispose of any leakage through the stem packing. Since the Type 304 stainless steel loop material is expensive, the layout has been made compact. The central reactor provides anchorage and the other components are flexibly supported so as not to restrict the movement of the short stiff loops.

The main coolant system is designed to transfer 1645 x 10^6 B.Th.U. per hour from the reactor core to the steam generators, which convert this heat into 1,840,000 lb per hour of saturated steam. Main coolant is circulated at the rate of 37·8 x 10^6 lb per hour, enters the reactor at 496 deg. Fah. and leaves at 533 deg. Fah. The total volume of the main coolant system is approximately 24,000 gallons. The normal operating pressure range in the main coolant system is 1850 lb to 2150 lb per square inch absolute. The main coolant system is designed to permit a normal rate of load change of temperature 10 per cent per minute without undue surge or pressure and fluctuation. If necessary, full secondary plant load can be dropped essentially instantaneously.

The chemical solution safety injection system of the reactor is designed to inject a large volume of boric acid solution into the core in the unlikely event of a large loss of coolant accident. Some minutes after such an accident and after the boiling out of any residual water surrounding the core in the reactor pressure vessel, the generation of decay heat could cause the core and its cladding to start to melt. Although it is possible for an amorphous mass of melted core, uranium oxide and stainless steel to reform a critical mass, this is not likely to occur. More important is the possibility of a release of a large quantity of gaseous and solid fission products, from the core material. To cool the core and maintain it in a sub-critical state, a large volume of borated water will be pumped into the main loops following any extraordinary accident. Since fuel changing requires filling the cavity over the shield tank with borated water, the large outside storage tank employed for this purpose is always full when the plant is in operation and is available as a source of boric acid solution for injection into the reactor and core. High pressure pumps are started in the event of a serious accident, and these flood the main coolant system with boric acid solution to cool the core and prevent meltdown. After the initial flooding, fresh solution is slowly added as required to continue to absorb decay heat given off by the core.

Fuel Handling System

Means are provided for the underwater removal of fuel assemblies from the reactor, for transferring the assemblies from within the vapour container to a water-filled storage pit situated outside of the vapour container, for storing spent fuel assemblies under water for a sufficient period of time to allow them to decay to a tolerable level, for inserting the spent fuel assemblies into lead-shielded shipping containers, and for removing the loaded shipping containers from the storage pit and loading them on freight cars.

The shield tank cavity, situated above and joined to the reactor vessel, is a stainless steel-lined concrete container filled during the refuelling operation with 25ft of borated water. This cavity is provided primarily for the purpose of permitting the fuel assemblies to be handled under water as they are withdrawn from the core with an overhead manipulator crane and grapple. The spent fuel storage pit, situated outside of the vapour container, is a stainless steel-lined concrete pit filled with 35ft of water and is provided for receiving spent fuel assemblies from the chute and storing them under water for a specified decay period. A manipulator crane and grapple handles the fuel assemblies and a travelling crane the shipping containers.

The fuel chute is an inclined 12in i.d. pipe interconnecting the spent fuel storage pit with the shield tank cavity within the vapour container. A hydraulically operated cone plug valve is provided in the fuel chute for the dual purpose of maintaining the integrity of the vapour container while the reactor is in operation, and for preventing the free discharge of borated water from the shield tank cavity to the fuel storage pit while the transfer of a fuel assembly is in progress. After unloading, a fuel decay period is required. After the period the fuel assembly is removed from the storage rack and inserted into its shipping container while under water.

When the reactor is shut down for refuelling, before the reactor water cools below 485 deg. Fah., borated water will be injected into the system to control reactivity. After power to the control rod latches is shut off, the rods will remain fully down in the core, but the mechanisms stay mounted on the vessel head; then their shield support is removed from over the vessel and the level of water in the reactor is lowered by draining. Then the operators will disconnect the electrical cables from the control rod drives, lift the coil stacks off the mechanisms, disassemble the control-mechanism cooling ducts, disconnect the in-core instrument thimbles and thermocouples, remove insulation from the vessel head, use stud heaters to help remove the fifty-two stud nuts and washers, place water-tight plugs in forty-eight stud holes, install guide plugs in the other four holes, use the polar crane to lift the vessel head ¼in to ½in, fill the tank cavity with borated water and equalise water level in the entire reactor system, remove the head and store underwater, use long-handled tools to remove the fuel hold-down plates, disconnect the control-rod drive shafts from the absorber sections, and use long-handled tools and a crane to remove the spent fuel elements one-by-one and load them on a carriage for transfer to the spent-fuel storage pool.

Primary Auxiliary Systems

The nuclear plant incorporated a limited number of auxiliary systems to effect plant filling, draining, make-up water purification, start-up, shutdown and decay heat removal. The charging and volume control system functions as a low pressure system to feed and bleed main coolant for purification or addition and removal of the shutdown chemical, and to maintain pressuriser water level on a long-time transient basis. The system incorporates a low pressure surge tank, three charging pumps, a regenerative heat exchanger, and letdown flow valves. In the interest of safety, all high pressure, high temperature and potentially radioactive lines are kept inside the vapour container. Consequently, the letdown valves are motor-operated and remote controlled. The low pressure surge tank performs simultaneously as a blowdown tank for pressuriser relief valves, a receiver for main coolant system surges, and a hydrogen container for the injection of hydrogen as a corrosion inhibitor and to some extent as a fission product gas stripper.

The main coolant purification system is designed so that the low pressure surge tank, in addition to the above duties, acts as a storage vessel for water to be purified and cooled. The purification system pumps discharge contaminated and impure bled main coolant from the low pressure surge tank through coolers and thence either to deborating ion exchange resins, mixed bed resins or the waste disposal system as required. In start-up, the bulk of the boric acid is removed by purging the main coolant system with pure water and discharging from the surge tank to the waste disposal system. The remaining boric acid is removed on an anion resin. When the boric acid has been reduced to a trace quantity, the purification flow is transferred to mixed bed resins for the most effective removal of ionic fission and corrosion products. In addition, the resins serve to filter insolubles such as iron oxides. The cooling of the 10 to 100 gallons per minute of water to be purified is accomplished on a "spared and shared" basis by using the cooler in the surge tank cooling system backed up by the shutdown cooling system. The storage and handling of the purification system resins have been designed to minimise capital investment and give additional flexibility in an area where resin consumption is subject to considerable speculation. A system of five resin capsules, 20 cubic feet each, is connected by quick-acting joints from their underwater operating positions in a concrete tank to the supply headers. When a resin becomes exhausted, the entire capsule,

THE AMERICAN SCENE *(continued)*

container and resin is disconnected and transferred under water to the storage area end of the water-filled concrete tank to decay. Sufficient storage volume for three years of spent resin accumulation is planned, after which time the heat output and activity level will permit dry storage or shipping to ultimate disposal. Physical handling of the spent resin eliminates the problems associated with fluidisation of resin beds and is conveniently adaptable to low-pressure purification systems.

A low-pressure surge tank cooling system is so integrated into the purification system and the shutdown cooling system to remove further heat from the low pressure surge tank fluid, with one pump and heat exchanger being provided. Identical equipment provided for the shutdown cooling system serves as a spare. The shutdown cooling system, which incorporates one pump and heat exchanger, serves to remove decay heat from the core when the main coolant system is depressurised. The initial stage of shutdown cooling is economically undertaken by using one of the steam generators as a cooler, until the coolant temperature has been brought below 370 deg. Fah. The shutdown cooling system is only placed in service at pressures below 250lb per square inch gauge when the main coolant system is depressurised for maintenance or when preparing for the refuelling operation.

The removal of decay heat from the spent fuel pit and the purification of spent fuel pit water are accomplished by a spent fuel pit cooling and purification system. Spares for this system are again provided by sharing coolant equipment and by cross-connection to the shutdown cooling system.

The component cooling system is used to remove heat from the main coolant pumps, the neutron shield tank, heat exchangers and other components as required, and to provide an additional closed barrier between potentially contaminated fluids and river cooling water. This is a duplicate equipment system using two pumps and two heat exchangers of full capacity. Other systems are also provided for corrosion control, sampling, venting and draining. The chemical shutdown system consists only of a mixing tank for boric acid which feeds by gravity to the suction of the charging and volume control pumps. The safety injection system for the prevention of core meltdown described previously was maintained separate and independent to ensure high integrity and maximum safety, but even this system shares the main loop charging piping, thereby reducing the number of lines and the penetrations into the main coolant piping.

Waste Disposal System

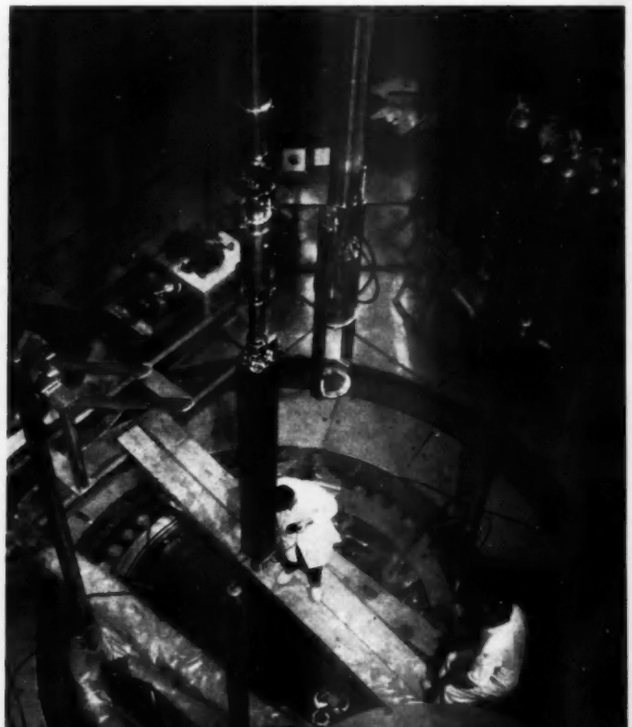
The waste disposal system receives, contains, adequately treats and safely disposes of all radioactive wastes in such a manner as to yield concentrated liquid wastes and ashes. Low activity level liquid wastes are discharged to the river after dilution with secondary plant effluent cooling water. Gaseous waste, after suitable dilution with fresh air, is dispersed to the atmosphere in small quantities and only under favourable meteorological conditions. Some airborne activity may be present in the vapour container atmosphere after depressurisation of the main coolant system. To permit entry into the container under these conditions, a purge system of filter banks and heating coils dilutes the air in the container.

The plant will be shut down periodically for refuelling, maintenance, and inspection. Because those systems which contain the moderator-coolant may become increasingly radioactive during plant lifetime, this contamination must be reduced where immediate access is desired. The decontamination system provides for the decontamination of isolated main coolant system loops, as well as of the pressuriser vessel. In order to refuel the reactor without hazard to personnel, facilities were provided for the remote underwater removal and transfer of the spent fuel assemblies from the reactor vessel to the spent fuel storage pit.

Reactor Operation

After the completion of construction work and the checking of the systems, the A.E.C. issued an interim licence on July 9, 1960, for the operators to load fuel, go critical and conduct tests up to 5MW (th). Within the next week, the reactor vessel and primary loops were filled with water borated to 1600 p.p.m. and the first of four start-up sources was installed on its source vane. After the temporary nuclear instrumentation was modified and a satisfactory base count established, the first of the seventy-six fuel elements were loaded into the core. Troubles with the fuel-handling equipment and nuclear instrumentation had to be corrected. The temporary neutron detectors had to be moved with respect to the sources and fuel after the first few elements were loaded because they gave a falsely high reading for the multiplication factor. After the core was loaded with fuel on July 26, the source-range detectors were replaced with detectors of greater sensitivity so as to produce satisfactory readings. Then the rest of the core structure was installed and the head was placed on the reactor vessel and bolted. To test the control-rod drives, each rod was dropped at least twice from the full-out position; all drop times measured less than the calculated two seconds from the initiation of scram.

The reactor went critical at 8.19 p.m., on August 19, 1960, after a smooth two-hour approach in accordance with written procedures. The nuclear instrumentation performed very satisfactorily. It has been calculated that



Figs. 13 and 14—(Left) Assembly of the low-pressure steam turbine for Yankee at the Lester turbine works of Westinghouse. (Right) Fuel element loading at the Yankee power station

criticality would be reached on a banked rod configuration with rods withdrawn 42in. But the reactor went critical with less withdrawal, indicating a slightly more reactive core or a greater rod worth than expected.

The reactor was then operated for familiarisation and further training purposes. During this period some of the coils for operating the control-rod coarse position were shorting out. Investigation showed that faulty venting might have let borated water leak into the coils, which, when it dried up, left boron crystals that earthed the coils. This was rectified by drying and cleaning the coils, and by improving the venting arrangement. Beginning on September 4, data were collected at low reactor temperatures so as to calculate control-rod and boron reactivity worths. Then temperature, pressure and flow coefficients of reactivity were measured at various temperatures and control-rod and boron worth were determined at operating temperatures. Other tests were run to learn hot scram rates, system heating rates and response of the neutron instrumentation when contol rods are positioned asymmetrically. During the September and October low-power tests, most of the bothersome troubles were with "hardware" rather than of nuclear origin; about 40 per cent of the low-power-test period involved maintenance of mechanical equipment. Although this maintenance work lost much time, it was used to advantage in that the personnel qualified to operate the reactor increased from five to twelve during this time.

Most of the mechanical troubles were of the sort encountered in starting a conventional power station, but the addition of nuclear design factors to normal engineering requirements gave rise to some new problems. For instance, to avoid gasket corrosion if the primary loops were to be decontaminated at some future time, it was specified that copper gaskets could not be be used in closures in primary-system components. Thus, hard nickel gaskets were used on the main coolant pumps. The pump flanges deformed badly and leaked after the system was heated up and cooled. After the flanges were scraped flat, the solution involved using soft copper gaskets and relying on differential thermal expansion to provide the final tightening of the closure.

The four non-return valves in the reactor system have been free of troubles. The eight parallel-disc stop valves hold the water at 2000lb per square inch with very low leakage. Stem packing leakage has been low with the valves in the open-backseated position. The 18in diameter "Flexitallic" gaskets on the manholes of the four steam generators have been another source of leakage. Although it was eventually possible to tighten the gaskets on the secondary side, it was necessary to seal-weld the closures on the 2000 lb per square inch primary side. Another leak occurred in the steam generators between the Type-304 stainless steel internal cladding and the carbon steel base metal at a point where the shell is pierced by a 1in diameter stainless steel instrumentation nozzle welded to the carbon steel.

To prevent the operating coils on the magnetic-jack control-rod drives from overheating to 600 deg. Fah instead of the 450 deg. Fah. for which they were designed it was necessary to reduce the voltage at which they operate as well as to redesign the entrance cooling ducts and provide better baffling to improve air distribution.

On July 29, the A.E.C. issued to the Yankee Atomic Electric Company a provisional licence for power operation up to 392MW (th) corresponding to 110MWe net. Thus, after the low-power tests, Yankee started producing electricity on November 10, 1960, and at 2.37 a.m. it first fed power into the New England grid. The plans were to spend four to five weeks bringing the reactor to the licenced 392MW (th) in four steps, while at each step calibrating nuclear instruments and controls, determining power coefficient, transients after loss of load, shield effectiveness, natural-circulation cooling, and reactivity variation caused by fission-product buildup and decay after changes in power. But turbine troubles interfered when the 1800 r.p.m. turbine reached steam rates where 70-90MWe were being generated. Due to partial admission of steam to a lower quadrant of the turbine and to insufficient space to allow the steam that had passed through the impulse stage to distribute around the full 360 deg. of the rotor before entering the reaction blading, a large unbalanced pressure resulted across the rotor, lifting it and causing serious vibration. Hence, on January 2, 1961, the plant was shut down while the two rings that support the first eight stages of reaction blading were removed and slotted to give space for the steam to flow. Two weeks later the corrections were complete and the plant was brought to its full licenced power of 120MWe gross, or 110MWe net. Yankee then began a 500-hour run to gather data in accordance with the licence provisions. This run continued with only three minor interruptions and ended on February 8.

The entire reactor and the turbo-generator were supplied by the Westinghouse Electric Corporation, the reactor pressure vessel by Babcock and Wilcox, the vapour container sphere by the Chicago Bridge and Iron Company, and the fuel handling system by the United Shoe Machinery Corporation.

Centennial of the Massachusetts Institute of Technology

No. I

THE Massachusetts Institute of Technology (M.I.T.) held its Centennial Celebration at Cambridge, Massachusetts, from April 2 to 10. M.I.T. is generally regarded as the senior engineering college of the United States—the American counterpart of the Imperial College of Science and Technology. Addresses by Mr. Harold Macmillan and Mr. Dean Rusk, the United States Secretary of State, on April 7 were the general highlights of the celebration. A four-day closed meeting entitled "International Conference on Scientific and Engineering Education" was attended by some 150 of the world's leading thinkers, representing more than thirty nations, who discussed problems now facing educators and society. The conferees represented one of the largest convocations of scientists, engineers and technological leaders to gather at an American educational institution. Although the International Conference was closed to spectators and the Press, a summary of the proceedings will eventually be made public.

On April 8, six public panel discussions were held on the respective subjects of "How Has Science in the Last Century Changed Man's View of Himself?"; "The Future of the Arts in a World of Science"; "The Future in the Physical Sciences"; "Arms Control"; "The Life of Man in Industry"; "The Future in the Life Sciences." In the evening, the President's banquet in honour of official delegates to the Centennial Convocation was held at the Hotel Statler-Hilton, in Boston, with an address by Dr. James R. Killian, Jr., chairman of the M.I.T. Corporation.

On Sunday, April 9, a colourful academic procession and Centennial Convocation was held in the Rockwell Cage. The procession had 700 persons in academic robes marching from the main building at M.I.T. to the Rockwell Cage on the West Campus. Dr. Julius A. Stratton, President of M.I.T., delivered the main address, after greetings expressed to the Institute by representatives of State Government, industry, alumni, faculty, students and educational institutions. The greeting from foreign universities were presented to the convocation by Professor John F. Baker, of Cambridge University.

While recalling all this official pomp and circumstance, it should also be mentioned that the students at M.I.T. have planned a centennial week-end of social festivities, from April 21 to 23, to follow the official M.I.T. Centennial celebration.

History of M.I.T.

M.I.T. was founded in Boston by William Barton Rogers, one of the leading geologists and natural scientists of his time, who had proposed a plan for a "school of practical science" as early as 1846. The charter was granted by the Massachusetts legislature on April 10, 1861, two days before the shelling of Fort Sumter and the outbreak of the American Civil War. Because of the war, the opening of M.I.T. was delayed until 1865, when six professors and fifteen students met for the first classes, held in rented rooms, until the first building, at Copley Square in Boston, was constructed and ready for use in 1866. Eventually the Institute had a dozen buildings, but growth made the facilities inadequate, and in 1916 "Boston Tech," as it was popularly known, moved to the

The engineering library, with its well-known dome

THE AMERICAN SCENE *(Continued)*

present site, in Cambridge, across the Charles River from Boston.

A university polarised around science, M.I.T. has five schools—the School of Engineering, School of Science, School of Architecture and City Planning, School of Industrial Management and School of Humanities and Social Sciences. It is a community of about 12,000 people, including some 6200 students (more than half of them undergraduates) and an instructural staff of more than 1200. It is of particular interest to note that 11 per cent of the current student population are from foreign countries.

Although education is its prime function, M.I.T. has made notable contributions through research in many fields, such as electronics, nuclear science, aeronautics and astronautics, computer technology, spectroscopy, solar energy, biology, food technology, nuclear engineering, naval architecture, servomechanisms, high-voltage engineering and chemical engineering. It has seventy laboratories, among them the Research Laboratory for Electronics, the Laboratory for Nuclear Science and the Computation Centre. The equipment for teaching and research include a 1MW nuclear reactor, supersonic wind tunnels, Van de Graaff electrostatic generators, a synchrotron, and a ship model towing tank. Scheduled to be completed in 1961 is a 600 MeV accelerator, being built and to be operated jointly by Harvard University and M.I.T. The world's most powerful magnet is to be constructed by M.I.T. by 1964. During World War II M.I.T. established the Radiation Laboratory, the principal centre for radar research and development in the United States, and other wartime laboratories which contributed to aircraft design, fire control, photography, chemical warfare and military medicine. In recent years it has conducted extensive research under Government sponsorship. The largest of its laboratories devoted to such work are the Lincoln Laboratory, in Lexington, Massachusetts, which has engaged in a wide range of activies related to national defence with particular emphasis on radar, communications, computer technology and solid state devices, and the Instrumentation Laboratory in Cambridge, the leading American centre for research on inertial guidance systems such as those controlling the ballistic missiles " Polaris," " Titan " and " Thor."

M.I.T. To-day

As any institution grows in size and breadth of interests, it is inevitable that from time to time questions will be raised as to whether its original purposes of organisation still represent the goals to be sought, or whether the goals should be redefined. Celebration of the Centennial at M.I.T. afforded an opportunity to give serious thought to this problem of goals. Introspection is part of the normal development process at M.I.T., as with any thinking group. It is taking place, to a degree, all the time, and possibly there is more danger in instability resulting from too much introspection than from stagnation resulting from too little.

As stated in the charter granted to M.I.T. on April 10, 1861, the Institute was established " . . . for the purpose of instituting and maintaining a society of arts, a museum of arts, and a school of industrial science, and aiding generally, by suitable means, the advancement development, and practical applications of science in connection with arts, agriculture, manufactures and commerce . . ." In carrying out the provisions of its charter the Institute has focused on three objectives ; the first primarily, the others secondarily : 1. The education of students. 2. The advancement of knowledge through research. 3. Service to Government and industry by consultation and research.

The overall strength of M.I.T. comes from the existence of an undergraduate school, a post-graduate school, and a strong research programme with free flow of ideas and people between these three activities. The undergraduate student benefits from the presence of the post-graduate school and the research activities in numerous ways. Research efforts provide a steady flow of new ideas which can be tested by presentation to post-graduate students and, as appropriate, can eventually be introduced into undergraduate teaching.

These research efforts provide an opportunity for members of the faculty and their post-graduate students to work directly on frontier problems. As a result of first-hand experiences they then bring enthusiasm and reality into their class-room teaching. Furthermore, experience indicates that the greatest opportunities for many students to engage in exciting thesis work stem directly from the involvement of their professors in research activities. Another very direct influence of the research is the substantial financial support these activities provide for post-graduate students. The undergraduate from the United Kingdom or from the Continent sometimes complains that faculty members in the United States are so engrossed in research that they have little time for students. However, if the research were eliminated the faculty would, of necessity, be reduced in size. The students might then have more contact with any one professor, but they would not benefit from the viewpoints of as many professors, and the ability of M.I.T. to attract and hold a first-class faculty would be greatly reduced.

Curricula in engineering at M.I.T. are much more " science-oriented " than at most American engineering colleges. Developments in this direction have occurred in an attempt to provide students with an educational foundation which will have enduring value and fit them for their whole professional career, rather than specifically for the first position they accept upon graduation. With the explosive growth that technology is now experiencing, detailed training related to specific devices or processes is apt to be outmoded before the student has had an opportunity to apply it. The phenomenal impact of semiconductor techniques on the electronics industry is an excellent example of revolution rather than evolution in the field of devices. However, a student trained to look at circuits in a fundamental way should be equipped with the background to permit him to make a transition from one class of device to another or to pioneer in the development of new devices.

One of the efforts receiving highest priority at M.I.T. over the past few years has been the enhancement of the effectiveness of laboratory teaching. Since " science-orientated " subjects tend to concentrate on the explanation of fundamental phenomena and to utilise a considerable amount of mathematics, it is essential that the engineering student be exposed to some of the physically tangible aspects of his field. The proponents of laboratory work have always felt contact with real devices was important, but oo often the types of laboratories they provided offered no real challenge for the student. Emphasis now is on helping the student develop techniques for experimental learning and letting him experience the excitement of tackling original problems, rather than merely making tests on an outmoded machine.

In an effort to create a teaching laboratory environment more nearly approaching that of the best industrial research laboratories, several of the laboratory subjects at M.I.T. are now being conducted in a way which permits students much greater flexibility in carrying out their experimental work. Instead of being restricted to the laboratory during a set period of only two to three hours, students in some laboratories are permitted free access at any time they choose during a whole day and are allowed to leave their individual set-ups intact during that period. With the opportunity for the student to do creative rather than stereotyped laboratory work and to conduct his experiments under somewhat more relaxed conditions both students and staff are showing great enthusiasm for laboratory subjects.

The provision of a faculty quality and the modern facilities for providing a technical education is inherently expensive. Over the years, M.I.T. has apportioned its attentions between teaching, research activities and service to Government and industry. While contacts with industry and Government place large demands on faculty time and energy, the Institute is convinced that, in the long run, the student benefits much more from the effort M.I.T. expends on these activities than he loses, because it is through the latter activities that the faculty and administration obtain much of the financial support for the Institute.

The Karl Taylor Compton laboratories for biology and food technology

(To be continued)

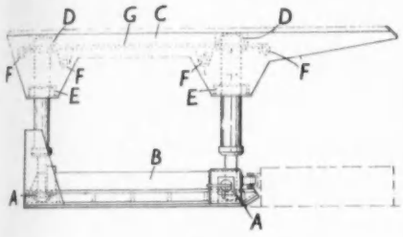
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

MINING EQUIPMENT

866,108. March 10, 1959.—ROOF SUPPORTING APPLIANCES FOR MINES, Gullick, Ltd., Kirkless Street, Wigan. (*Inventor : Donald Thomas Walsh.*)

This invention is for mine roof supporting appliances, particularly roof supporting chocks comprising a number of hydraulic props located between a base and a roofing bar structure and adapted to force the roofing bar firmly against the roof. One form of hydraulic chock, according to the invention, is described, by way of example, with reference to the drawing. The chock comprises a base frame, a roofing bar structure and four hydraulic props. A point to note is that the legs have their rams lowermost and the cylinders uppermost. The base has sockets for the feet of the hydraulic leg rams which are held in the sockets by resilient bushes *A* secured by caps. The feet of the rams have spherical underfaces which rest in spherical seatings in the sockets and a clearance between the ram and the hole in the cap provides for controlled movement between the leg and the base member. The base frame also supports and houses a double-acting ram *B* used to drag or push the chock and to move a coal conveyor or other mechanism up to the face as cutting of coal proceeds. The roofing bar structure comprises two bars C which are extended at one end of the chock to provide a canopy. The roofing bars are of box-section for a portion of their length and have rubber or like bushed upper and lower sockets *D* and *E* for the cylinders of the hydraulic legs which have convex upper faces. The bars are tied together by rods *F* secured in rubber or other resilient bushes in the side walls of the bars. Thus the roofing structure can



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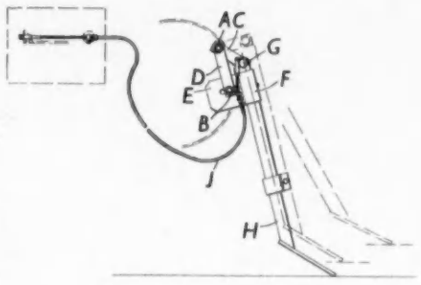
accommodate itself as a whole and the roofing bars can accommodate themselves individually to the proper setting of the chock. A cover plate *G* extends between and is secured to the outermost tie-rods. In this design the roofing bar takes all or substantially all bending stresses, i.e. those due to both vertical and horizontal roof movement, the base serving merely to distribute the load over the floor. Thus, the base and particularly the supports on it for the hydraulic legs need not be of very massive construction, the strength of the chock being incorporated primarily in the roof-bar and canopy. This design gives a high strength-to-weight ratio and less depth of the face is occupied by mechanical members, giving greater freedom of passage through the chock. The manner in which the roofing bars are connected together by the tie-rods facilitates the assembly being split down into two " goal post " chocks if required.—*April* 26, 1961.

TRACTORS

865,960. February 4, 1960.—ANTI-REARING DEVICE FOR TRACTORS, Andrew Oliver Hemus, 16, Gavell Road, Cobham, Surrey.

This anti-rearing device for tractors provides a simple means which cuts out the engine of a tractor when the front wheels leave the ground due to the machine operating at too steep an angle or being subjected to excessive draw-bar strain. Referring to the drawings, two of the pillar nuts on the differential housing of a tractor are replaced by extended hexagonal pillar nuts *A*, *B*. The pillar nut *A* carries a movable link *C* which is retained by a distance plate *D*. The nut *B* is secured to the lower end of the plate *D*. A plate *E* has a slot through which a cylindrical part of nut *B* projects. The plate E has a sleeve *F* and slidable in the sleeve is a tube pivoted on a bolt *G* at its upper end. In this tube is an adjustable leg *H*, the lower end of which has a foot shaped so as to prevent the building up of " trash." Pivotally



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connected to the link *C* is a Bowden cable *J* connected to the normal means for stopping the engine. The foot is adjusted for operation so that it is about 4in from the ground according to the conditions prevailing. Should the tractor assume a dangerous position, as, for instance, when negotiating a steep bank or mound, or when subjected to excessive draw-bar strain causing it to rear, the foot contacts the ground and the leg is forced up. This rocks the link *C* which pulls the Bowden cable to stop the engine by cutting off the fuel supply.—*April* 26, 1961.

WELDING

866,456. June 5, 1959.—GAS WELDING, Imperial Chemical Industries, Ltd., Imperial Chemical House, Millbank, London, S.W.1. (*Inventors : Cyril Albert Terry and Edwin Albert Taylor.*)

This invention relates to the gas welding of copper-base alloys containing nickel. It is usually desirable that the weld metal should be of the same composition as the base metal or as nearly so as possible, but with filler materials hitherto available for gas welding cupro-nickel such welds are invariably porous. It has been found that by modification of the filler material used the soundness of the weld can be improved. According to the present invention there is provided a method of gas welding copper-base alloys containing 5—30 per cent nickel, and, optionally, up to 5 per cent iron and/or up to 2 per cent manganese which comprises adding as filler material an alloy of copper and nickel containing 0·1 to 1·0 per cent of titanium, up to 5 per cent iron and/or up to 2 per cent maganese; the nickel, iron, and manganese contents of the filler material being substantially the same as those of the alloy being welded. The preferred range of titanium content of the filler material is 0·2 to 0·5 per cent. It is preferable to use a flame which is substantially neutral, but slight variations away from this condition do not significantly affect the quality of welding. Using such a flame, sound oxy-acetylene welds were made in 80/20 cupro-nickel plate 3/16in thick with filler material in accordance with the invention containing 80 per cent copper, 20 per cent nickel and 0·5 per cent titanium. The presence of iron up to 5 per cent and manganese up to 2 per cent in the parent metal and in the filler material has no adverse effects on the properties of the weld.—*April* 26, 1961.

AIRCRAFT

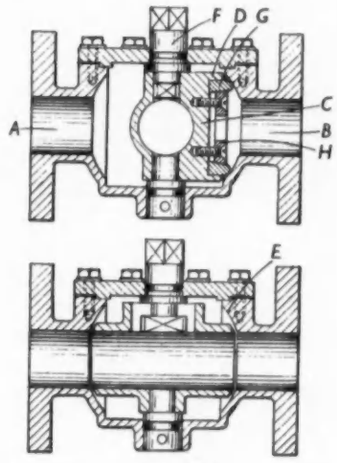
866,228. July 20, 1959.—TAKE-OFF INDICATORS FOR AIRCRAFT, Kelvin and Hughes Ltd., Kelvin Works, Kelvin Avenue, Hillington, Glasgow, S.W.2. (*Inventor : Alexander Anderson Brown.*)

Take-off indicators for aircraft may be required to display either or both of the following : (*a*) The available runway length ahead of the aircraft, or, in other words, the " distance to go," ; (*b*) The excess acceleration, namely the difference between the actual acceleration and the acceleration needed if the aircraft is to take off within the " distance to go." Both these quantities require a measurement of the distance travelled by the aircraft, but if use is made of the rotation of an under-carriage wheel in order to effect this measurement an error is introduced because of the variation in effective diameter of the wheel when the load on the tyre is reduced by increasing lift. A variation in effective diameter of as much as 10 per cent may occur. This invention has for one of its objects to provide an indicator in which the error is substantially eliminated. The take-off indicator incorporates means responsive to the rotation of an undercarriage wheel to generate a voltage dependent upon rotation. A further means responsive to changes in the weight exerted by the aircraft upon the wheel applies to the voltage a correction suitable to compensate, at least partially, for changes in effective diameter of the wheel with changes in the weight. The equipment responsive to rotation of the wheel may be arranged to generate either an alternating or direct voltage proportional to the speed of rotation. The unit responsive to the changes in weight may be a strain gauge or an extension potentiometer, the output of which is dependent upon the relative movements of the undercarriage oleo. By integrating the corrected voltage from the generator and subtracting this voltage from a preset voltage corresponding to the runway length there can be derived and indicated the " distance to go." It is important that any drop in thrust which would result in the aircraft being unable to take off within the " distance to go " should be indicated immediately and there are also provided means for differentiating the voltage to produce a further voltage representative of the actual instantaneous acceleration of the aircraft. Additional means compare this further voltage with the output of an acceleration/time unit programmed in such a manner that its output varies with time from the commencement of take-off and is representative of the instantaneous minimum required acceleration. Equipment responsive to the comparison indicate when the actual acceleration falls below the minimum required acceleration.—*April* 26, 1961.

VALVES

865,388. November 27, 1958.—VALVES, J. Brooksbank, Ltd., Embsay, Skipton, York. (*Inventor : Harry Gallagher.*)

This invention provides a valve which can be used in either direction of flow. Referring to the



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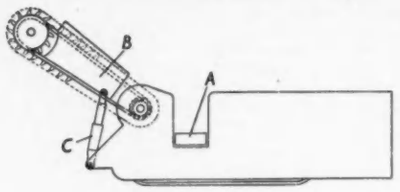
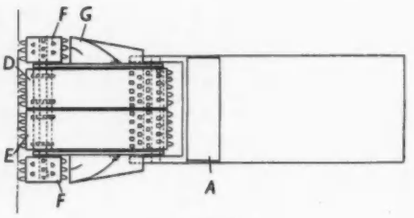
drawings, a valve housing has aligned inlet and outlet ports *A* and *B*. The valve plug *C* is inserted into the housing through an opening in the top, closed by a bolted cover plate. The plug consists essentially of a hollow trunk which in the open position of the valve is in axial alignment with the inlet and outlet ports and provides an uninterrupted tubular connection between them. In the closed position of the valve, as shown in the upper view, a shaped boss portion *D* on the plug faces a part-spherical land *E* surrounding a valve port. Fixed in a central aperture in the bottom of the housing is a vertical bearing in the form of a stub pin mounting a sealing ring and an upstanding cylindrical shank which forms the bottom pivot for the plug. An operating spindle *F* is mounted centrally in an aperture in the cover plate, and a cylindrical portion of the spindle is grooved to take a sealing ring. A sealing ring *G* of rubber is set in a recess in the boss portion of the plug. This ring has an outer cylindrical surface fitting the wall of the recess and its projecting top has an approximately semi-circular section. The inner face of the ring is slightly conical to co-operate with the shaped clamping ring *H* by which it is secured to the plug by screws.—*April* 19, 1961.

MINING MACHINES

866,144. February 9, 1959.—MINERAL MINING MACHINES, Coal Industry (Patents), Ltd., Hobart House, Grosvenor Place, London, S.W.1. (*Inventors : Alan Partington and Ronald Louis John MacRae.*)

A machine constructed according to the invention, as shown in the drawing, has a main body which carries the drive and other ancillaries (not shown) and is provided with a cross-conveyor *A*. Pivotally connected to the body at the front end of the machine is a cutting frame *B*. This frame can be pivoted in a vertical plane relative to the body by hydraulic jacks *C* on each side and extending around the frame are two belts, *D* and *E*, of cutter picks. Extending transversely of the cutting frame





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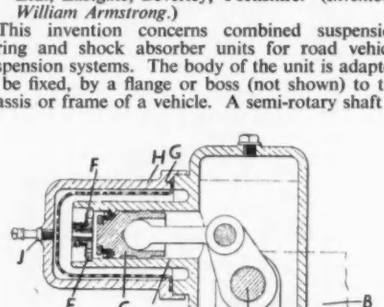
and rotatably mounted in the free end is a driven shaft which has projecting from each end a drum *F* from the periphery of which project cutter picks. Each drum has an axial width equal to one-third that of the cutting frame. The drum cutter picks, when they face forwards, are aligned with the outer ends of the picks of the belts *D* and *E*. Mounted one on each side of the cutting frame is a guide *G*, to deliver material cut on to the belts *D* and *E* on to the cross-conveyor.—*April* 26, 1961.

ROAD VEHICLES

867,500. October 4, 1957.—ROAD VEHICLE SUSPENSION SYSTEMS, Armstrong Patents Company, Ltd., Eastgate, Beverley, Yorkshire. (*Inventor : William Armstrong.*)

This invention concerns combined suspension spring and shock absorber units for road vehicle suspension systems. The body of the unit is adapted to be fixed, by a flange or boss (not shown) to the chassis or frame of a vehicle. A semi-rotary shaft *A*



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is journalled in bearings in the body and at one side it is attached to a lever arm *B*. The shaft is coupled through a crank and crank pin to one end of a connecting rod having its other end formed as a ball which is pivotally secured within a piston *C*. The cylinder *D* is closed by a head plate *E* with a central boss which has a tapped bore. The head plate also has a number of holes spaced at intervals around the boss. A valve member *F* has a cylindrical portion axially slidable on the outside of the boss and an external flange adapted to close the bores in the head plate. A flanged plug is threaded in the bore of the head plate and its flange provides an abutment for a spring which urges the valve plate *F* into the position illustrated. Thus a passage defined by the bore and valve provides communication between the cylinder bore and outside it. The cylinder is enclosed by a dome shaped diaphragm *G*, which in turn is enclosed and surrounded by a dome *H* so that a totally enclosed chamber is formed between the diaphragm and the internal walls of the dome. In this chamber air is stored under pressure. Stored under an equal pressure is hydraulic oil, enclosed in the chamber formed between the internal walls of the diaphragms *G* and the head of the piston *C*. The dome has an air inlet non-return valve *J*. In use the body, which is partially filled with oil, may be secured to the frame or chassis of the vehicle and the lever arms *B* arranged as the upper or lower links in a wheel suspension, with the load acting to rotate the shaft *A* anti-clockwise. In such an arrangement the load urges the piston to the left, tending to compress the hydraulic medium against the diaphragm, thereby compressing the air, which thus functions as a suspension spring, with a progressively increasing rate. Further variation in the rate characteristic may also be attained by virtue of the geometry effect of the crank mechanism, i.e. in dependence upon the angle initially defined, in the rest position of all the moving elements, between the crank and the piston rod. The behaviour of the pneumatic spring is capable of being varied by adjusting the initial quantity of air enclosed between the dome and the diaphragm. Shock absorbing is effected by the hydraulic medium, the flow of which is controlled in both bump and rebound directions by the bore in the plug of plate *E*. If, however, an excessive bump is encountered the valve *F* is unseated, allowing oil to escape from the cylinder through the holes round the plate. Alternative forms of the device are described in the specification.—*May* 10, 1961.

Catalogues and Brochures

CARTER GEARS, Ltd., Thornbury Road, Bradford, 3.—Folder AMI, giving details of the new 10 h.p. size AM26 Carter hydraulic variable speed gear.

INDIA TYRE AND RUBBER COMPANY, Ltd., P.O. Box No. 5, Inchinnan, Renfrew.—Booklet covering in great detail many of the facets of tyre performance.

C. A. E. C. HOWARD, Ltd., St. John's Works, Bedford.—Illustrated folder describing a wagon tippler which is marketed under the name of "Trucks-a-daisy."

RANSOMES AND RAPIER, Ltd., Waterside Works, Ipswich.—Publication describing "RapieR" 6 and 7 standard mobile cranes for handling loads up to 38,000 lb.

THE BELMOS COMPANY, Ltd., Bellshill, Lanarkshire.—Technical publication No. P.A. 90 : 10, entitled "Motor Control and Distribution Gear, Safeguards Against the Explosion Hazard."

BRITISH NYLON SPINNERS, Ltd., 68, Knightsbridge, London, S.W.1.—Leaflet on nylon car harness, explaining what happens in a crash and how safety harness can save lives and prevent injury.

CAMREX PAINTS, Ltd., Camrex House, Hudson Road, Sunderland.—Industrial sales handbook containing details of the company's primers, undercoats, finishing coats and special coatings.

CAWKELL RESEARCH AND ELECTRONICS, Ltd., Scotts Road, Southall, Middlesex.—Leaflet describing the "Tele-Remscope," type TRI, with which a still picture from the moving sequence on a closed-circuit television can be obtained.

CLAYTON DEWANDRE COMPANY, Ltd., P.O. Box No. 9, Titanic Works, Lincoln.—Leaflets describing the "Clayton-Still" wire-wound heat transfer tube for use in heat transfer between oil and air, water and oil, water and gases, and in refrigeration.

ENGLISH ELECTRIC VALVE COMPANY, Ltd., Chelmsford, Essex.—Folders on magnetrons, high vacuum variable capacitors, valve replacement data, and image orthicon television camera tubes ; also a publication on travelling wave tubes (N1/5) describing the construction, operation and characteristics of hese devices, with application notes and abridged data on the English Electric range.

SAMUEL FOX AND CO., Ltd., Stocksbridge, near Sheffield.—Book entitled *Alloy Steels*. Although this book is published by Samuel Fox and Co. it is not a catalogue of the firm's products. It is a collection of technical data on a selection of constructional alloy steels set out in a variety of ways so as to be of maximum use to metallurgists. In addition to data showing the effects of alloy composition, of mass and heat-treatment on the mechanical properties of steel, the book includes information on the newer concepts of hardenability, isothermal and continuous cooling transformation. Copies are obtainable from Samuel Fox at £2 2s. each.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, May 26.—NOTTINGHAM BRANCH : Grange Farm, Toton, Ladies' Night, 7 p.m.

Fri., June 2.—BRIGHTON, HOVE AND DISTRICT BRANCH : New Imperial Hotel, First Avenue, Hove, Sussex, Films, 7.30 p.m.

DRAWING OFFICE EQUIPMENT AND MATERIALS EXHIBITION

Mon. to Thurs., June 5 *to* 8.—Royal Horticultural Society's New Hall, Westminster, London, S.W.1, First National Exhibition

INSTITUTE OF MARINE ENGINEERS

Thurs., June 1.—NORTH MIDLANDS SECTION : British Iron and Steel Research Association, Hoyle Street, Sheffield, "The Need for Research in Diesel Engine Development," R. V. Hughes, 7.15 p.m.

INSTITUTE OF PETROLEUM

Wed. to Sat., June 7 *to* 10.—Old Swan Hotel, Harrogate, Summer Meeting. Theme, "Information and its Dissemination."

INSTITUTE OF ROAD TRANSPORT ENGINEERS

To-day to Sun., May 26 *to* 28.—Savoy Hotel, Blackpool, Annual Business Conference.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., May 30.—Royal Commonwealth Society, Craven Street, London, W.C.2, Symposium on Biochemical Engineering, 2.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., May 30.—UNWIN MEMORIAL LECTURE : Great George Street, Westminster, London, S.W.1, "The Work of the Institution's Research Committee," J. F. Baker, 5.30 p.m.

Thurs., June 1.—Great George Street, Westminster, London, S.W.1, "Auckland Harbour Bridge : Design," Gilbert Roberts and O. A. Kerensky, and "Construction," H. Shirley Smith and J. F. Pain, 5.30 p.m.

Tues., June 13.—Great George Street, Westminster, London, S.W.1, Annual General Meeting, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon. to Fri., May 29 *to June* 2.—Summer Meeting in London.

Tues. to Thurs., June 20 *to* 22.—SOUTH MIDLAND CENTRE : Diamond Jubilee Celebrations with visits to the North Staffs. Sub-Centre, Rugby Sub-Centre and to the Main Centre in Birmingham.

INSTITUTION OF MECHANICAL ENGINEERS

Sat., May 27.—Joint Annual Summer Visit of the Graduates' Sections of the Institutions of Civil and Electrical Engineers to London Airport.

Wed., May 31.—YORKSHIRE BRANCH : Summer Visit to George Bassett and Co., Ltd., Sheffield, 2.10 p.m.

INSTITUTION OF PLANT ENGINEERS

Sat., May 27.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, "Acoustics," E. G. Ewing, 7.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., June 14.—1961 Viscount Nuffield Paper, Large Lecture Theatre, Engineering Faculty, The University, Bristol, "Some Aspects of Engineering Progress," Sir Willis Jackson, 6.30 p.m.

INSTITUTION OF PUBLIC HEALTH ENGINEERS

Fri., June 9.—SUMMER MEETING : Caxton Hall, London, S.W.1, Annual General Meeting, 4.30 p.m. and "The Development of Bracknell New Town with particular reference to its Effect on Local Government Administration," H. Charlesworth, 6 p.m.

Sat., June 10.—Visit to Bracknell New Town and recently completed works of special interest.

ROYAL AERONAUTICAL SOCIETY

Fri., June 2.—ROTORCRAFT SECTION : Lecture Theatre, 4, Hamilton Place, London, W.1, "Development of Stabilising Equipment of Helicopters," P. D. Macmahon, 6 p.m.

ROYAL SOCIETY

Thurs., June 8.—Burlington House, Piccadilly, London, W.1 "The Rapid Measurement of Intensity with an Oscillating Fabey-Perot Spectrometer : Isotope Abundance in Mercury," D. J. Bradley, and "Precise Measurements of the Density of Mercury at 20 deg. Cent., II. Content Method," A. H. Cook, 4.30 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., June 14.—"Hope House," 45, Great Peter Street, Westminster, London, S.W.1, Annual General Meeting, 7 p.m.

Advanced Engineering Courses

A Summer School in Health Physics (Radiation Protection). DEPARTMENT OF CHEMICAL ENGINEERING AND CHEMICAL TECHNOLOGY, Imperial College, South Kensington, London, S.W.7. The course, which runs from July 3 to July 14, is designed to provide basic information on principles, but will include detailed lectures on certain topics which are essential to an understanding of the subject. It is suitable for graduates in science or medicine and should be of interest to radiation protection officers in the universities or in industry, medical officers of health, factory inspectors and others concerned with radiation protection. The syllabus will include lectures on basic physics, biological effects of radiation, genetics, the external radiation hazard, hazards from bone-seeking isotopes, measurement of the radioactivity of the body, radiochemical laboratory design and management, natural activity of food and water, waste disposal and legal aspects. Practical work with radioactive materials, and visits to other establishments, will form part of the course. Fee £26 5s.

Post-Graduate Course in Engineering Production. THE UNIVERSITY OF BIRMINGHAM, Edgbaston, Birmingham, 15. The primary object of this post-graduate course of studies, which occupies one adacemic year, is to provide advanced education and training for production engineering and management positions in industry. Graduates of Birmingham and other Universities, with degrees in science subjects and with satisfactory industrial experience, and other students with equivalent qualifications, are eligible for admission. A systematic course of studies on the principles of engineering production and on industrial management subjects is provided together with suitable practical work in the form of special research projects and case studies in industry. Application for admission to the course commencing each October should be made to the Registrar not later than July 30. Fee £95.

Post-Graduate Course in Operational Research and Allied Studies. THE UNIVERSITY OF BIRMINGHAM, Edgbaston, Birmingham, 15. The object of this post-graduate course of studies, which occupies one academic year, is to provide advanced education and training for graduates who intend to take up careers in operational research in industry. Graduates of Birmingham and other Universities with first or second class honours degrees in science, mathematics or economics (with statistics) and some industrial experience are eligible for admission. A systematic course of studies is offered, leading to examinations in six subjects. In addition, each student is required to undertake an investigation of a practical industrial problem and to submit a report for examination. Application for admission to the course commencing each October should be made to the Registrar not later than July 30. Fee £95.

Welding Technology. THE COLLEGE OF AERONAUTICS, Cranfield, Bletchley, Bucks. A one-year post-graduate course which will take place during the Autumn, Spring and Summer terms of the academic year 1961–62. Autumn term commences on October 9. The purpose of the course, which has been sponsored by the Institute of Welding and the British Welding Research Association, is to provide students of graduate status in either metallurgy or engineering with a specialised training to fit them for posts in the design, development and production departments of the many industries where welding is now vital. A range of subjects will be covered with a particular concentration on the special metallurgical considerations inherent in welding ; the welding processes, their characteristics and fields of application, and design for welding and the essential production techniques. Fees, British students £75 ; Commonwealth students £250 ; foreign students £350. Residence £126 10s.